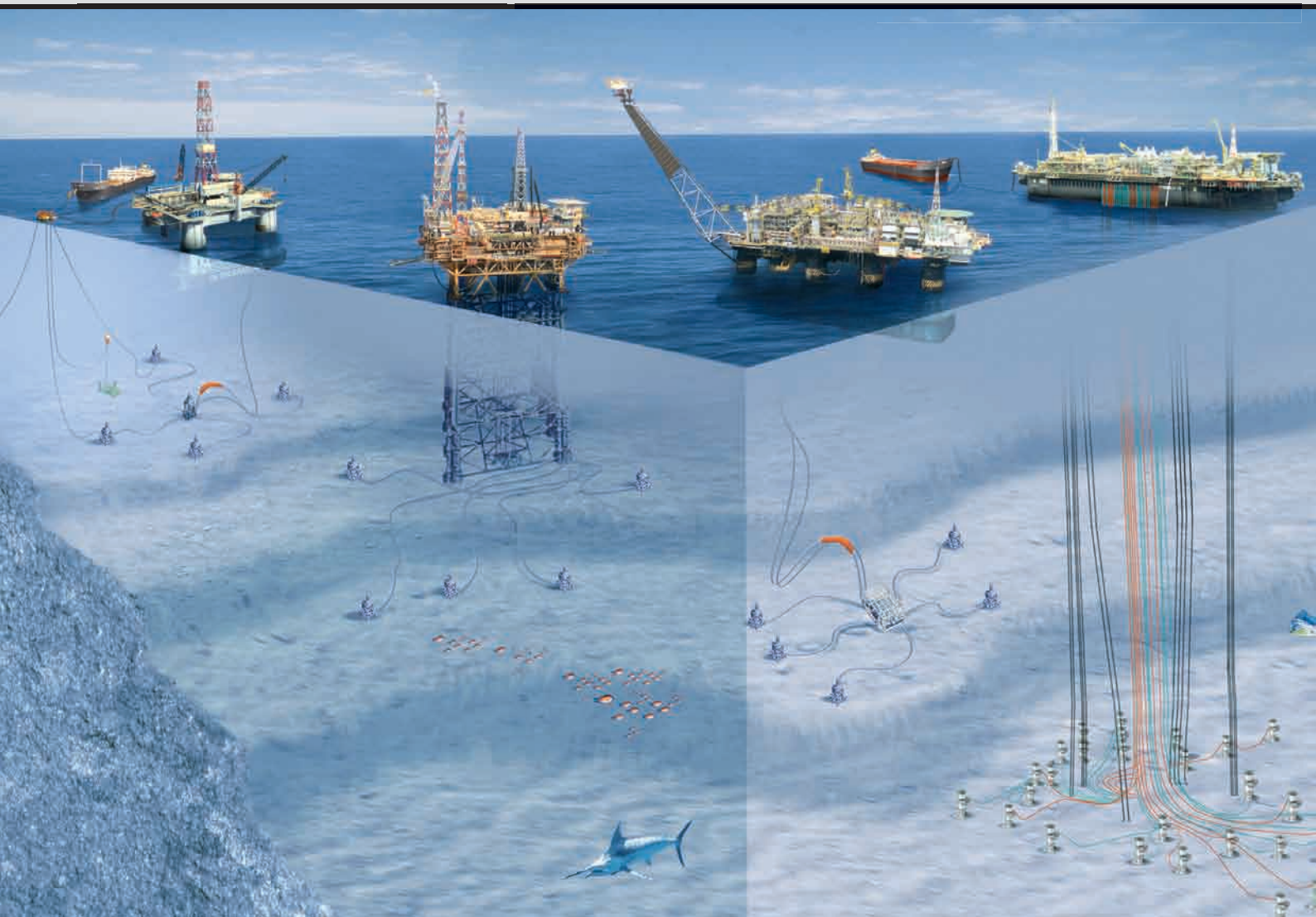


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Brazil oil & gas

Inside





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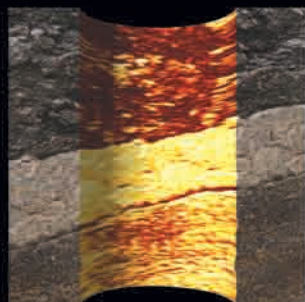
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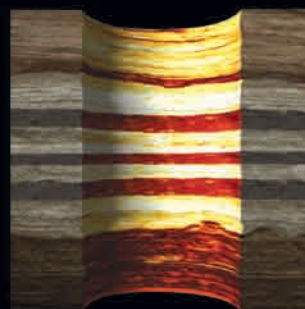
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Petrobras' Propoço Looks to Top Quartile Performance

A 'roadmap' for realising top performance, *Propoço* emphasizes extensive planning, best practices and information sharing as the way forward. Consequently, it applies 'thresholds' or minimal requirements and 'benchmarks' or standards for projects, personnel, wells and documents. By propagating best practices it promotes efficiency.

By looking at the processes and flow of information behind planning, drilling and completing an Oil or Gas well, *Propoço* will help engineers plan wells from inception to drilling and completion. Not just by using chronograms but detailed well engineering studies including all necessary calculations and designs for a specific well.

The backbone of the program is a comprehensive analysis of *Petrobras* well engineering activities and recommendations on areas for improvement. *Propoço* is based on four distinct programs with the overall *Propoço* management plan considered separately.

The second program – *Information Management and Performance Evaluation (INF)* – seeks to recommend KPI and adopt minimum performance standards. It also seeks to permanently and systematically compare *Petrobras* well engineering with other oil companies and as a result identify and adopt best practices. It also aims to define a standard well-engineering documentation system.

Propoço – Petrobras' program for Excellence in Well-Engineering

The third program – *Continuous Process Management and Standardization (PROC)* - seeks to review the management of well-engineering processes especially those related to standardization, in order to develop a system that is less bureaucratic and fit-for-purpose based on critical success factors and the actual needs of users. It also seeks to review the way 'lessons learned' and non-conformance are applied.

Based on a simplified operational version of Petrobras' PRODEP model – *Project Management, Planning and Controls (PROJ)* -- is the fourth program within Propoço. PROJ focuses on implementing a well design and approval system using an integrated management approach. The

well design and approval system is split into three stages – concept, draft and management plan – combining scope, cost, quality, risk, team, supply/procurement and communication.

The fifth program – *Knowledge and Workforce Management (CON)* - is concerned with attracting, training and retaining technically capable people within well-engineering functions. It also identifies needs for well engineering competency areas as well as allocating technical personnel where necessary. Additionally, it develops specialists, integrates technical communities as well as creating tools and standards for engineering processes. 🔥

Key Performance Indicators (KPI) are routinely used by Oil companies to measure operational performance. In drilling, for example, a common indicator is a Depth v Days curve. Using a graph, specific well construction events are plotted against the duration or time taken per event. This highlights 'flat-spots' showing the occurrence of downtime or NPT (non-productive time). Worldwide, the average value for NPT varies between 20-30% of overall well construction time. Oil companies with the highest performance levels typically exhibit NPT between 10-15%.

Petrobras launched the Propoço program which aims to place the company in the top quartile of well construction performance by improving

the well planning process and reducing NPT associated with well construction and maintenance.

The potential gains are clear; reduced NPT means more wells completed with fewer rigs. For example, achieving a reduction of 10% NPT from an overall NPT of 20% translates into a net saving of 10% of rig-time and consequently rig-cost. When the NPT reductions are applied across more rigs the savings soon stack up. 10 or more rigs, the performance gains effectively mean an extra rig, free-of-cost. For an oil company that has 30 rigs and manages to reduce NPT by 10%, this effectively means 3 fewer rigs which lowers demand for rigs while constructing wells more quickly.

Petrobras Pres



Q: Brazil Oil & Gas - Can you describe some of Petrobras' Social & Environmental activities?

A: Mr Gabrielli - Petrobras has added to its core business the principles of human rights, labor, environment and fighting against corruption, when in 2004 it joined one of the most important projects of corporate social responsibility in the world, the Global Compact.

The company set a new performance benchmark in the area of Social Responsibility when it launched the Petrobras Zero Hunger Program on September 1, 2003, agreeing to invest R\$ 303 million by the end of 2006 in actions to strengthen public policies against poverty and starvation. Many actions are being implemented throughout Brazil, with direct participation of the

communities, contributing towards a better quality of life for the Brazilian population.

By means of a public selection process, the company chooses projects that are aligned with the Program's activities, with priority given to education and professional training, jobs and earnings, guaranteed rights of the child and adolescent, and social and volunteer projects.

Petrobras is a company committed to Sustainable Development. When it interacts with the environment and uses its natural resources, the company is aware that it should render accounts to society on the impact of its operations on the biosphere, and contribute towards a better quality of life for the population. Accordingly, the company has enormous socio-environmental responsibility and invests in programs that not only defend environmental preservation but also encourage

President Interview

the development of ecological awareness within the communities.

Over the past three years, Petrobras has invested around R\$ 5.2 billion in the environmental security of its facilities and more than R\$ 18 million in projects with environmental sponsorship, such as the Tamar, Humpback Whale and Manatee projects, for example. With its 50th anniversary in October 2003, the company launched the Programa Petrobras Ambiental. The Program, with projects chosen through a public selection process, considers investing R\$ 40 million for the first two years.

Q: Brazil Oil & Gas - What Gas Pipeline plans and LNG projects are underway?

A: Mr Gabrielli - The gas pipeline network Petrobras is either currently constructing or that it plans to build involves total investments of R\$15 billion (R\$12.5 billion through 2010) and deploying liquefied natural gas (LNG) projects, which are budgeted at R\$5 billion (R\$2.9 billion through 2010). The main projects are the following:

Urucu - Manaus gas pipeline: Extending for 662 km, this pipeline will transport natural gas produced in Urucu to Manaus. The project includes building a pipeline between Urucu and Coari to flow the liquefied petroleum gas (LPG) production. It is slated to go online in the first quarter of 2008 and to involve investments nearing R\$1.26 billion.



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Southeast - Northeast Gas Pipeline (Gasene): Designed to fully interconnect the Southeastern gas system to the Northeastern one, the project includes the Cacimbas - Catu, Cacimbas - Vitória and Cabiúnas - Vitória sections. Together with the gas pipelines in the Northeastern Network, such as the Catu-Carmópolis (265 km long, with a flow of 9.1million cubic meters a day, and with operations foreseen to commence in the second quarter 2008), it involves investments of R\$4.6 billion through 2010.

Southeastern Network: Campinas-Rio Gas Pipeline construction, which will extend for 453.6 km, be capable of transporting 5,800,000 cubic meters a day of natural gas, and involve total investments estimated at R\$862.5 million.

Liquefied Natural Gas (LNG): Projects are currently being studied to contract converted vessels to re-gasify the LNG which will be installed in the Guanabara Bay (Rio de Janeiro) and in the Pacém Port (Ceará). This project is hoped to go online in the first quarter 2009, involving investments of some R\$2.0 billion through 2010.

Q: Brazil Oil & Gas - Is any growth in Production foreseen?

A: Mr Gabrielli - To maintain long-term growth in production, Petrobras has been boosting its exploratory portfolio. It currently has, for future exploration, more than a hundred blocks purchased in National Petroleum, Natural Gas and Biofuel Agency (NPA) auctions. Additionally, it has exploration agreements in several other countries, allowing it to set a production goal of 4,556,000 barrels per day for 2015. For the end of the decade, the forecast is a total oil and gas production of 3,493,000 barrels per day, 2,925,000 of which is from Brazilian fields.

Q: Brazil Oil & Gas - How will Refining be improved?

A: Mr Gabrielli - The projects to enhance and modernize Petrobras' refineries will broaden the processed load by 100,000 barrels per day and raise the processed Brazilian oil volume by 250,000 barrels per day (from 80% to 90% processed load). The R\$22.6 billion in investments (by 2010), involving work in all Petrobras refineries, also hope to improve fuel quality, rendering it "cleaner," and having an important socio-environmental effect too.

Improved diesel fuel quality will prevent emissions calculated at upwards of 86,000 tons of CO₂ per year, contributing to better quality of life in the cities.

Petrobras in Numbers

Data referring to the year 2007

NET EARNINGS (R\$ million)

R\$ 170.578

NET INCOME (R\$ million)

R\$ 21.512

INVESTMENTS (R\$ billion)

R\$ 45,3

SHAREHOLDERS

272.952

EXPLORATION

70 rigs (43 offshore)

RESERVES (SEC CRITERION)

11.704 billion barrels of oil and gas equivalent (boe)

PRODUCTIVE WELLS

12.935 (738 offshore)

PRODUCTION PLATFORMS

109 (77 fixed; 32 floating)

DAILY PRODUCTION

1.918 barrels per day (bpd) of oil and LPG
382.000 barrels of oil equivalent of natural gas per day

REFINERIES

15

YIELD FROM REFINERIES

1.965 million barrels a day

PIPELINES

23.142 Km

TANKER FLEET

153 (54 belonging to Petrobras)

GAS STATIONS

5.973

FERTILIZERS

3 Plants: 235,000 tons of ammonium, 100,000 tons of urea

Sustainable self-sufficiency

Reaching sustainable self-sufficiency has always been a goal for Brazil and, thus, Petrobras; it means reducing the country's vulnerability to international oil market fluctuations, i.e., Petrobras has to keep production above demand in the long run. Petrobras' trajectory until it achieved self-sufficiency was marked by large investments in technological advancements, by deepwater drilling records, and by the countless improvements it made in its many activities.

Brazil's most important oil province, the Campos Basin, was discovered in 1974. This was a mark towards self-sufficiency. In the following years, Petrobras received the OTC award twice for the technological innovations it made in the giant Roncador field production project, in the Campos Basin.

In the late 1970s, the average Brazilian production was 200,000 barrels a day, while consumption reached 1,115,000 barrels per day. The challenge then became discovering large reserves to increase production. That was when the company launched the Oil Sector Action Plan, which defined resources to increase production already aiming at self-sufficiency.

In the 1990s, Petrobras became the world's main deepwater producer, with about 65% of the area of its offshore exploratory blocks located at depths of more than 400 m. This was the outcome of technological investments and programs such as the Procap – program for the Technological Development Program for Deepwater Exploration Systems – aimed at improving the company's technical competency in producing oil and natural gas in deep waters. The positive results led the company to launch the Procap 2000 and, later, in 2000, the Procap 3000, focused on ultra-deepwater exploration.

The domestic oil production reached the 1.54-million-barrel-a-day mark in 2003, about 91% of the country's by-product demand. The domestic production goal set forth by Petrobras' 2015 Strategic Plan is 2.3 million barrels per day by 2010. To achieve this feat, 15 large oil production projects will be deployed by 2008.

The unit is part of an oil system that includes 34 production units, fixed and floating, and produces about 1.4 million barrels of oil per day. The platform was responsible for increasing Brazil's oil and gas production figures by 7% in 2006, and it will soon also be able to compress 6,000,000 cubic meters of gas a day and store 1.6 million barrels of



Petrobras-50

oil. In partnership with Repsol YPF, which owns 10% of the project, Petrobras invested R\$1.95 billion to develop the field. This total includes expenses with drills, drilling, and with the vessel's conversion, which cost about R\$650 million.

Forecasts up to 2010

In addition to the P-50, another three, smaller platforms also went into operation in 2006:

P-34 (60,000 barrels per day), in the Jubarte Field; SSP-300 (20,000 barrels per day), in the Piranema Field; and the FPSO Capixaba (100,000 barrels per day), in the Golfinho Field. At this same field, the FPSO Cidade de Vitória (100,000 barrels per day) went into operation in 2007.

These platforms allowed Petrobras to wrap up 2006 with an average daily production of 1,910,000 barrels - above the national oil demand. The expectation is that by 2010, the average production will gradually increase more than consumption every year. By the end of 2008, for example, the projections indicate the average consumption will be some 2,000,000 barrels a day, while production is expected to top out at 2,100,000 barrels a day.

Projections for 2010 are even more optimistic. It is estimated the average national production will reach 2,300,000 barrels a day, while consumption is forecast to be around 2,060,000 a day. The 2006-2010 Business Plan foresees investments in the order of R\$28 billion in exploration and production to consolidate self-sufficiency and obtain the surplus that will allow us to even plan oil exports or improve our negotiation position in the international market.

Platform types

Get to know the main types of Petrobras platforms.

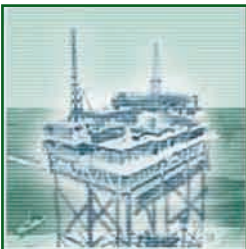


FPSO platforms - FPSOs (Floating, Production, Storage and Offloading vessels) can process and store crude oil, and offload the oil and/or natural gas. A process plant is installed on the ship's deck to separate and treat the fluids from the wells. After the crude is separated from the water and gas, it is stored in tanks on the actual vessel and then offloaded to a relief ship every so often.

The relief vessel is an oil tanker that moors on the FPSO stern to receive the crude stored in its tanks and then transport it onshore. Compressed gas is sent onshore through gas pipelines and/or injected back into the reservoir. The larger FPSOs have a daily processing capacity of some 200,000 barrels of oil, with an associated gas production of approximately two million cubic meters a day.



Round-hull FPSO - type platform This is a pioneering FPSO platform for its round-hull shape, and the first to produce, store and offload oil. The platform produces in deep waters, ranging from 1,000 to 1,500 meters. The round shape increases stability in the sea, since the waves circle the vessel. Its hull, made out of two layers of steel plates, is more versatile and stable, allowing operation under much more severe environmental conditions and affording the vessel more safety with regard to oil leakage into the sea.



Fixed platforms - These were the first units to be used. Preference has been given to them in fields located in water depths to 200m. Fixed platforms generally consist of modular steel structures installed at the operation site with piles driven into the seabed. Fixed platforms are designed to receive all drilling equipment, material storage, and staff accommodation, plus all well-production facilities.



Jack-up platforms - These consist basically of a barge fitted with a support structure, or legs that when activated mechanically or hydraulically, are lowered until they reach the seabed. The platform is then raised above the water level to a safe height, away from the action of the waves. These platforms are mobile and are pulled by tugboats or are self-propelled. They are designed to drill exploratory wells on the continental shelf in depths varying from 5 to 130 meters.



Semi-submersible platforms - Semi-submersible platforms consist of a structure of one or more decks supported by submerged pontoons. A pontoon moves in accordance with the action of waves, currents and winds, and this may damage the equipment that is to be lowered into the well. That is why it must be set in position on the surface of the sea, within a tolerance radius dictated by the sub-surface equipment. Two kinds of system are responsible for positioning the pontoon: the anchoring system and dynamic positioning system.

The anchoring system consists of 8 to 12 anchors and cables and/or chains, like springs that produce efforts that can put the pontoon back in position when it is moved by the action of the waves, winds and currents.

In the dynamic positioning system, there is no physical connection between the platform and the seabed, except in relation to the drilling equipment. Acoustic sensors determine the driftage, while the computer-controlled propellers in the hull bring the platform back into position.

Semi-submersibles may or may not be self-propelled. In any event, they are more mobile and are preferred for drilling wildcat wells.



Drill ships - A drill ship is a vessel designed to drill subsea wells. Its drilling tower is located midship, where an opening in the hull allows the drill string to pass through. The drill ship positioning system, consisting of acoustic sensors, propellers and computers, cancels out the effects of the wind, waves and currents that tend to move the ship from its position. ●

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Sourcing and retaining highly Skilled Personnel and enhancing Capital Projects are not only desirable but also essential in modern day business. PricewaterhouseCoopers' admirable reputation and unrivalled expertise ensures it can help companies overcome these challenges and maintain a leading position in the industry.

Marcos Panassol has been with PwC Brazil for over 25 years and has been a partner since 1997. Currently, he is the industry leader for the Oil & Gas segment in Brazil. He also served as the audit partner for Petrobras for 5 years through 2002, and certain of its subsidiaries.

Marcos speaks to Brazil Oil & Gas about two of the main challenges faced by the energy industry today, and how PwC can help resolve these issues.

Q: Brazil Oil & Gas - Why is attracting and retaining a skilled workforce a challenge today?

A: Marcos Panassol - The rapidly aging workforce, combined with the downturn of students in the energy fields such as petroleum engineering and geology, is generating new concern for companies. According to a John S. Herold report, upstream oil and gas companies are likely to lose more than 60% of their employees by 2010. Attracting and retaining good people is now more difficult than ever. Three quarters of CEO's believe that talent is one of the top three sources of competitive advantage and that lack of key skills is one of the biggest threats to their business. With growing demand for energy, companies need greater production and a larger workforce.

As people issues rise up the business agenda, HR functions need to adopt a more strategic perspective. But many HR functions lack the skills required to help business leaders make strategic decisions about the work force. Developing human resource strategies that help attract new recruits, as well as retaining the experienced workforce, their knowledge and skills, is imperative to the future of the industry.

Q: Brazil Oil & Gas - How can PwC help companies overcome this hurdle?

A: Marcos Panassol - Our multi-disciplinary approach allows us to advise on all aspects of people management, helping our clients to enhance value for their businesses through people. Our solid grounding in areas such as tax, compensation, benefits, pensions and HR data metrics are the bedrock of our approach to consulting with clients. For example:

a) International Assignments (IA): Our IA services specialists help multinational Oil & Gas companies plan,

implement, manage and support the entire international assignment process.

b) Reward Planning: Creating the right reward plans for the company's employees is essential for attracting and retaining key staff, achieving business and human resource objectives, as well as optimizing related costs. But balancing business priorities with shareholder interests can be a challenge. By blending the compensation, benefits, pension and financial expertise of our global network, we help organizations link executive and employee rewards to business goals and shareholder value.

c) Change Management Effectiveness: PwC has established a strong reputation for helping clients cope in the face of changing business conditions around the world and across industries. PwC offers Oil & Gas companies a complete range of services, tailored to the industry issues.

Q: Brazil Oil & Gas - What are the main issues that companies need to face when it comes to Capital Projects?

A: Marcos Panassol - The number, size and complexity of Capital Projects have grown dramatically. According to a PwC Global Project Management Survey, only 2.5% of companies delivered their project within time, cost and scope, including the initially projected business benefits.

Large capital projects are usually exposed to risks such as unclear requirements, inadequate planning, lack of stakeholders' commitment or a set of critical competencies, inability to anticipate obstacles, as well as lack of resources, structure or insufficient controls, etc. Organizational structures are ever more complex and there is increasing pressure for quick results. On time delivery of projects, within costs and requirements are not enough. For a project to be considered successful, it

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must also prove that the proposed goals have been met, it adequately managed change and transition, and that it has also met the stakeholders' expectation with the realization of the business benefits originally anticipated.

In order to increase the chances of success of a project, Oil & Gas companies must anticipate risks, and implement efficient process, procedures and controls in order to assure the attainment of the expected results.

Q: Brazil Oil & Gas - What solutions can PwC provide in this respect?

A: Marcos Panassol - PwC can help manage Capital Projects, improve the quality of the information and provide an independent view of all project dimensions. We can also help to reduce costs and maximize benefits, through the use of a proprietary methodology, which includes the processes of assessment and monitoring of projects and inherent risks.

The benefits companies can obtain are:

- Pro-active alerts, reducing risks
- Transparency to investors
- Monitoring of the results and benefits realization
- Improvement in the governance of projects
- Adequate communication to different stakeholders

During the last 14 years Marcos has been working in the Rio de Janeiro office, serving major multinational and Brazilian companies in various segments.



Currently Marcos devotes most of his time as the Oil & Gas leader, developing relationships and opportunities as well as according PwC's advisory services to Petrobras, which is an SEC registrant with shares traded in the New York Stock Exchange.

Additionally, Marcos is a member of PwC's Global Capital Markets Group and, in that capacity, coordinates the technical consulting and audit services, both under US GAAP and IFRS, provided to Brazilian companies seeking funds in the US and International markets. 🔥

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First Field Applications of Microflux Control Show Very Positive Results

Helio Santos and Erdem Catak, Impact Solutions Group, Joe Kinder, Secure Drilling, Emmanuel Franco and Antonio Lage, Petrobras, and Paul Sonnemann, Chevron ETC

The Microflux Control (MFC) method is a new managed pressure drilling (MPD) technology that was designed to improve drilling in most conditions, from simple wells all the way to high pressure, narrow margin, offshore and other challenging wells and to significantly increase safety through automated kick detection and control.

The system operates using a closed loop drilling process that allows for real-time identification of micro influxes and losses and the control and management of downhole pressures through an automated data acquisition and computerized pressure control system. After the successful tests conducted with water and oil based mud at the Louisiana State University Well Control Facility in 2005 and early 2006, the system was taken to its first wells in the summer and fall of 2006 with Petrobras and Chevron.

MPD wells can be divided in basically two categories:

- Standard, where the well is statically overbalanced;
- Special, where the well is statically underbalanced for at least a portion of it.

The MFC can be used with either options, but the first two wells drilled and herein described used the Standard option. As the well is drilled statically overbalanced,

all operational procedures, including safety and well control, remain the same. There is no need to change well design criteria or safety, and the main goal is to provide a way of safely reducing the mud weight towards the pore pressure. Very little training is required, and can be provided at the well site for the rig crew in less than one hour.

The Special mode, on the other hand, requires much more elaboration in terms of well design. There is a need to review the operational procedures, including connections, tripping, casing, logging, cementing, and especially safety and well control. Training is extensive and there is a need for expert personnel at the location during drilling. And



Figure 1 – Manifold in use during the first well for Petrobras in Brazil. The small footprint was an important factor in gaining the rig crew's acceptance.

additional equipment is also another item that needs to be considered, making it more difficult in some cases due to footprint restrictions of some rigs, not to mention the higher cost associated with it.

Field Application Objectives

The objectives of the first wells drilled for Petrobras and Chevron using the MFC were to confirm in field applications the accuracy of the measurements observed from the system during the tests at LSU, prove the capability of the system to be used with cuttings at high rates of penetration and demonstrate the reliability and repeatability of the overall system. For each of these objectives, the system performed successfully in the field.



Figure 2 – Rotating head and the connections to the manifold. Drilling procedures, including tripping and connections were all normal, without changes.

Standard MPD - How Was Drilling Conducted?

As the Standard MPD mode was used in both wells, the choke was fully opened while drilling, and during connections the pressure was allowed to reduce to zero. The goal during connections was to confirm what information could be obtained when the pumps were off. Flow out was continuously monitored and, if the well happened to be statically underbalanced, it would be immediately detected. While drilling the system was ready for action at all times; if a kick was identified the choke would be closed automatically to control the influx.

The rotating control head used on both wells was rated at 500 psi dynamic. When using the Standard MPD option, this low pressure is more than enough for the vast majority of cases as back-pressure would be applied to control an influx.

Prior to each section, before drilling the cement and casing shoe, a series of flow exercises was conducted. Fingerprinting of pipe movement, back-reaming, and flow out when starting and stopping the pumps is critical for identification of abnormalities while drilling.

First Well - Petrobras - Brazil

In early 2006, Petrobras decided to perform a four well evaluation program of the MFC technology. Even though the major interest of Petrobras is to use the system in their deep and ultra-deepwater operations, the four-well program contemplated starting with a simple land well and progressing to more complex scenarios. A shallow

exploratory well was the first selected for the program. A Petrobras Kelly equipped rig without any automation was chosen with the objective of confirming the capability of the system to be used on virtually any rig. The first well was drilled in August 2006 in the Northeast of Brazil using a water-based drilling fluid.

The first well contemplated the use of the MFC for the 8 ½" section. The installation of the system was conducted while the rig was drilling the first phase with the hard pipe needed for the operation prepared and welded at location. When the BOP was installed, the rotating control device was mounted, all the connections made, and the 8 ½" section was ready to be drilled using the system (Figs. 1 and 2).

While the rig up was being conducted, a simple introduction of the system was made to the company man, tool-pusher, mud engineer and rig crew. Very quickly they understood the potential benefits of the system and were very supportive. The small footprint of the manifold and simplicity of the system were two important points that attract their positive behavior towards the system.

A total of 1,824 ft (556 m) of the 8 ½" section was drilled in five days without any problem presented by the system. During this period three cores were taken with the flow returning from the well kept through the MFC manifold. The coring operation was all conducted while using the MFC, which proved another non-invasive characteristic

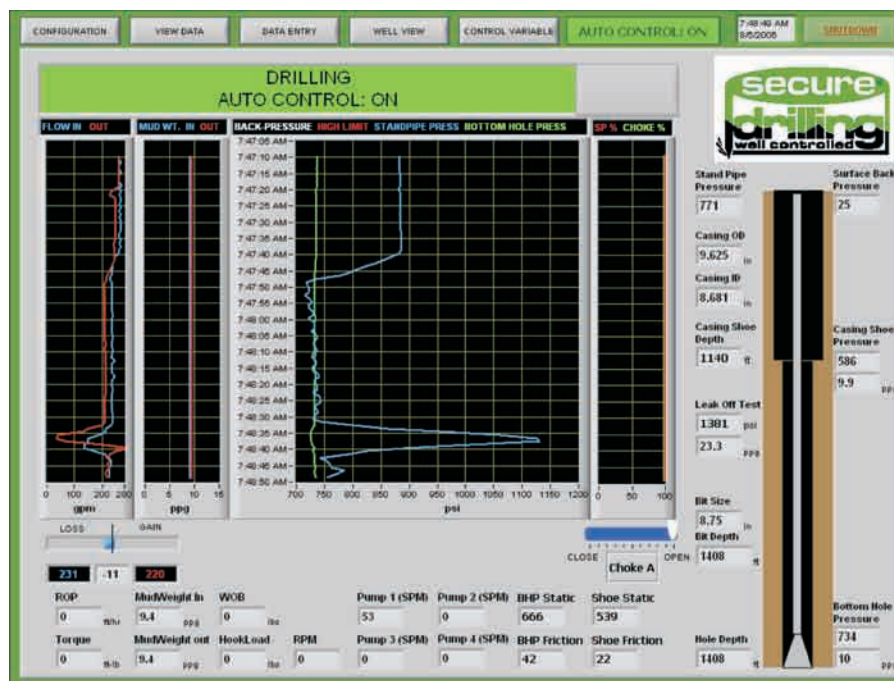


Figure 3 – Tight hole while moving the pipe up. Surge in pressure was 400 psi. PWD would not have detected this event due to slow frequency of data acquisition and transmission and due to the position of the sensor in the annulus.

of the system. Flow in was taken from stroke counters. In addition to the MFC manifold with its flow meter and back pressure sensors, a standpipe pressure sensor was also used. Information gathered during the drilling of this well included the impact of pipe movement on flow and flow measurements, the confirmation of the benefits of using a top drive versus a Kelly on the wear life of the element in the rotating control device, the interplay between the MFC system and the rig drilling controls, and the type and display format of drilling data from the MFC system that the drillers considered important and helpful.

With the information obtained from this first well, several improvements were made to the system. The first improvement was to add a remote panel in addition to the control panel located in the dog house. The purpose of the new remote panel is to allow the operations to be monitored from a location outside the rig floor. This additional panel was found to be very useful for the company man, tool pusher and Petrobras personnel responsible for the operation. Another improvement identified during the test was to locate one remote panel in front of the driller so that he could see the measurements being acquired with the system and compare that data with other data gathered by the rig (implemented in

the second well for Petrobras). In addition, the project identified improvements in screen layout, the processes for screening potential kicks and loss data when the rig is not drilling, addressing anomalies created by pipe movement and in the interface with the driller.

The results of the first well for Petrobras confirmed the system ability to operate in the field under very warm condition, identify changes in flow on a real time basis and be installed on most rigs with minimum modifications.

One of the first positive results seen is shown in Fig. 3. While moving the Kelly up to make a connection there is a sudden increase in stand pipe pressure, and a reduction of flow out and then flow in. Back-pressure did not increase (not shown in the figure), confirming that this event occurred inside the wellbore and it was most probably caused by a tight spot while moving the pipe up. Assuming that the most likely place in the drillstring to find a tight point is at or close to the bit it can be concluded that a choke was suddenly created inside the wellbore and that spike in pressure was transmitted to the bottom of the wellbore in a matter of seconds. Due to its high frequency and accuracy of the pressure sensors an event like this could be detected by the MFC and confirmed by the flow measurements and surface measurements that it was caused by a tight spot inside the annulus. This

observation has various consequences, especially related to Pressure While Drilling (PWD) measurements. Due to the low frequency of data transmission and position of the pressure sensor of the PWD tool, it is very unlikely that any PWD tool would have spotted this event. And what is critical is that this occurrence could have triggered a loss circulation incident, by inducing a fracture, for example, and it would be important for future well planning and optimization of drilling operations in the same field.

Second Well - Chevron – South Texas

In September 2006, the MFC system was used on a deep well in South Texas for Chevron. This well was drilled using an oil-based drilling fluid and a larger and more sophisticated automated rig equipped with a top drive. The second well, following the planned increase in complexity and difficulties, was more challenging than the first one in many respects. First, the rate of penetration (ROP) for the well was at times close to 300ft/hr and in the 12 ¼" section the flow rates exceeded 700 GPM. The mud weight also reached more than 17 ppg by the end of the 8 ½" section at 13,000 ft.

In order to have the possibility of conducting additional tests, including experiments with leak-off test and higher pressure procedures, rig connection to the MFC system had both low pressure and high-pressure lines to allow testing to be made when the rig's BOP was closed.

The first test on the Chevron well was conducted while drilling the 12 ¼" section. The objective was to demonstrate the system ability to handle high flow rates and a significant cuttings load. In this test, the system operated without any problem at close to 800 GPM with an ROP of more than 250 ft/hr. The back-pressure generated at surface during drilling was small, confirming that the next section (8 ½") could use the system without any problem.

Before drilling out the cement and the 9 5/8" shoe, flow tests were conducted to identify the flow conditions with pipe movement, back-reaming and reaming back to bottom and to fingerprint what would be a normal condition for pump shut down. Fig. 4 shows the pipe moving down when reaming back to bottom, and Fig. 5 shows the fingerprint for pump shut down with flow reaching zero after some time on a decreasing trend. Tests were also conducted to confirm the system ability to consistently hold a desired back pressure. This procedure is part of the standard steps to be done with the system before drilling out the shoe (also conducted during the first well). A total of 2,775 ft (845 m) of the 8 ½" section were drilled in seven days without problems. Repeatability and reliability of the system was confirmed with this longer well.

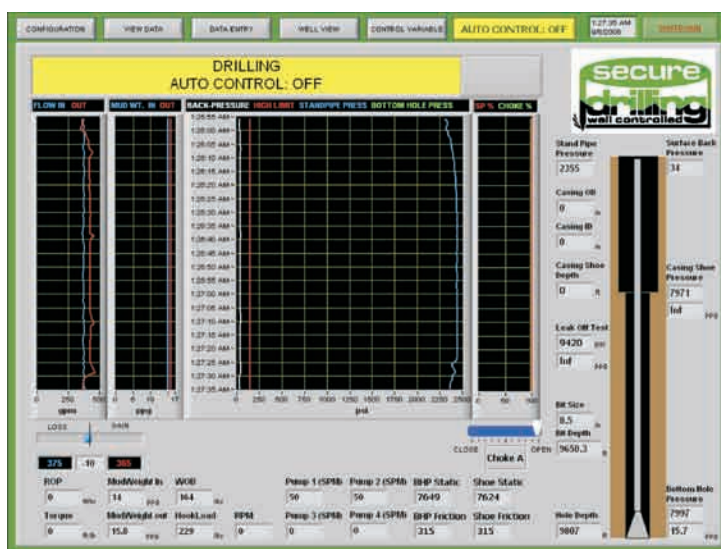


Figure 4 – Fingerprinting of pipe movement (going down). Observe the gain indicated by the displacement of the wet string. When moving the pipe upwards flow out indicates a loss equivalent to the volume of the wet string being removed from the well. The accuracy of the method is confirmed by the tool joints clearly shown by the upsets in the picture.

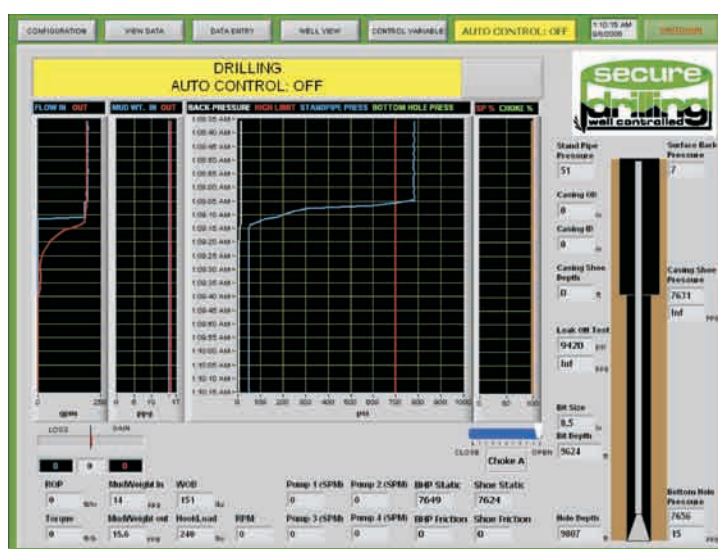


Figure 5 – Fingerprinting of a pump shut down for connection inside the casing. Flow out goes to zero after sometime, on a decreasing trend.



Figure 6 – Influx detected during one connection. Observe the difference from the normal behavior shown above.

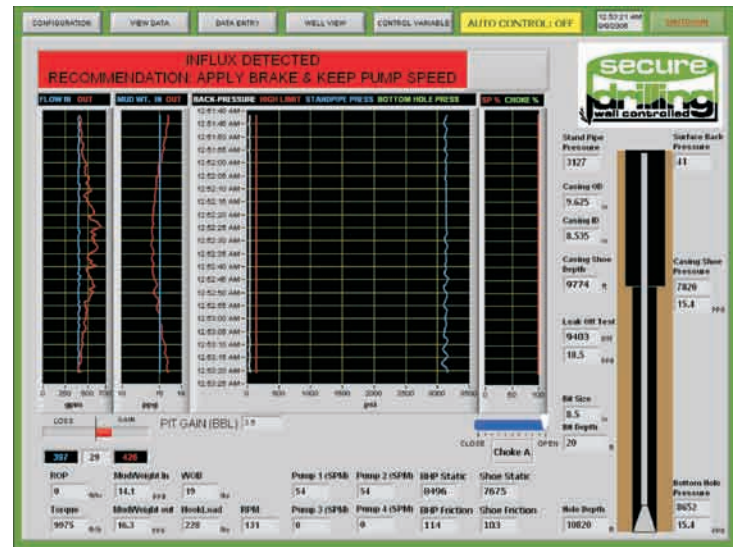


Figure 7 – The gas which entered during the connection appeared at the surface after one bottoms-up. Observe the increase in flow out and the decrease in density out, confirming the gas was at the surface.

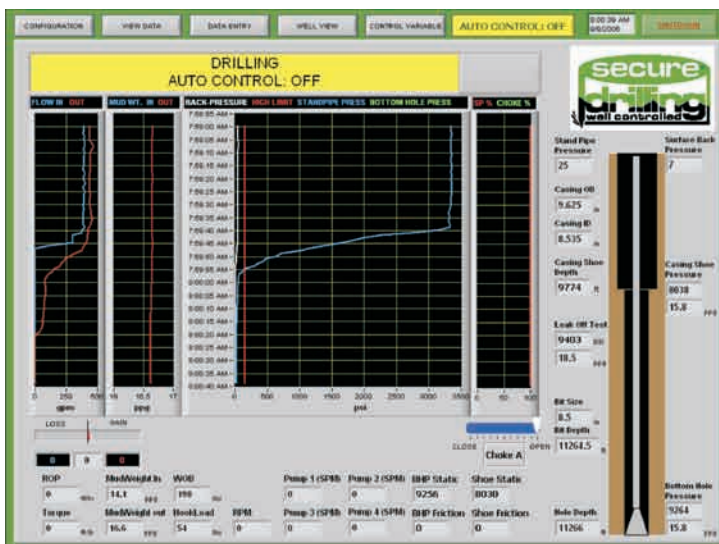


Figure 8 – After increasing the mud weight, the following connection presented a normal behavior again, with no signs of influx. Mud weight increase was managed by observing the gas influxes during the connections.

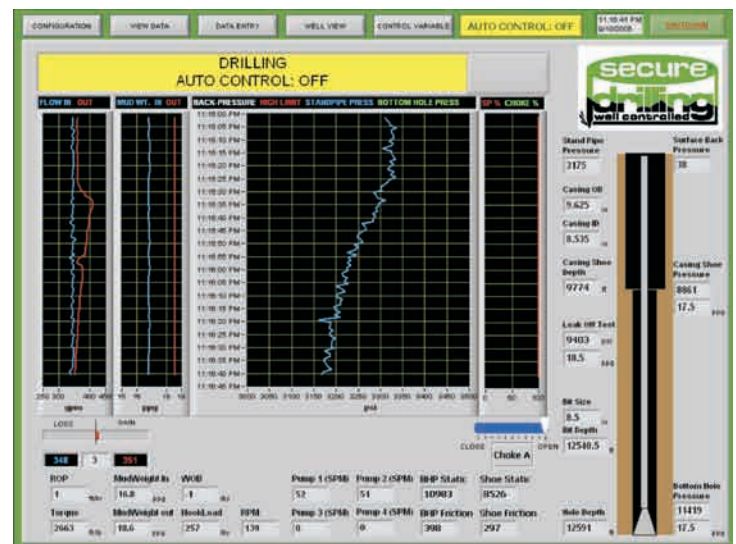


Figure 9 – Gas kick being swabbed during back-reaming, prior to a connection. Observe the flow out curve showing a gain, rather than a loss, which would be a normal behavior, as described in Fig. 5.

Events While Drilling

A few connections after drilling out the shoe presented the first interesting observations. Flow out did not go to zero as expected for a normal connection, and the system immediately identified the influx occurring (Fig. 6). A direct comparison with Fig. 5 can be made, confirming the abnormal behavior. Even though in real-time it was not possible to confirm the nature of the fluid entering the well, bottoms-up later it could be seen that the fluid entering the well was indeed gas (Fig. 7). This was also confirmed by mud logging. The flow out increased and density out decreased, confirming that the gas had

reached surface, as these indications were from the flow meter located at the manifold. A small increase in mud weight was implemented and the next connection indicated a normal behavior as can be seen in Fig. 8 (the mud weight in was not updated yet in this figure, this data was entered manually at that occasion).

A few connections further, the procedure was to back-ream twice before making the connection. Fig. 9 shows one event where the gas is being swabbed while back-reaming, and Fig. 10 shows that some extra gas is clearly seen when the pumps are off compared to the previous ones already shown, Fig. 5 and Fig. 6. The amount of

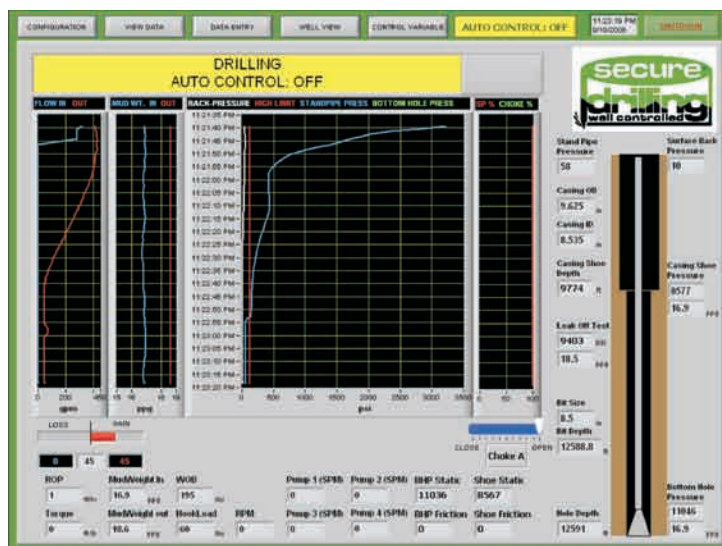


Figure 10 – The amount of gas this time during the connection is much bigger due to the swabbed kick. Compare this connection with the one in Fig. 6.

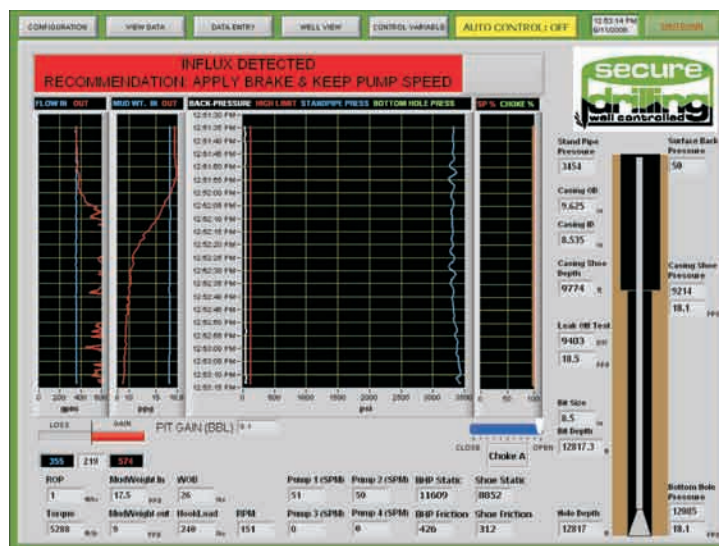


Figure 11 – The confirmation of the higher amount of gas comes after one bottoms-up. This time it took almost four minutes to clear the gas at the surface, compared to less than two minutes in the previous event shown in Fig. 7. All these events were correlated with the mud logging present during the well. Density out was reduced to a lower level than in Fig. 7 as well, showing the gas fraction was also higher.

gas that entered the well was again adequately correlated when the gas reached surface. Fig. 11 and Fig. 12 show the amount of time required to clear the gas at the surface, much longer than the previous event described in Fig. 7, which took less than two minutes to clear. With the ability to clearly see a swabbed kick, the system confirms the extreme accuracy very important when drilling close to the pore pressure, as it is the aim of any MPD job.

In summary, the second well demonstrated two important attributes of the MFC system:

- First, the well confirmed the effect of pipe movement on the flow out measurement in the system identified in the first Petrobras well. In particular, this result showed the capability of the system to identify minute changes in flow with pipe movement.
- Second, it confirmed the system's ability to detect small influxes during connections and kicks being swabbed in. At more than 12,000 ft and using an oil-based mud, the system was able to detect small deviations in flow when the pumps were shut down to make a connection. The static mud weight would be increased slowly and

the “normal” connections and the “abnormal” ones were very clearly observed. After the increase in mud weight, the following connections would show no influxes until a higher pore pressure zone was crossed again.

The information gained during the Chevron Texas well demonstrated that the influxes observed in real-time during drilling were directly correlated with the gas shown from the mud logging at the location, usually detected at least one hour later. Depending on the volume of the influx taken during the connection it was possible to observe, with the system, the gas influxes in real time and follow them to surface.

Lessons Learned and Next Steps

The basic lessons learned from the first two wells using the MFC Drilling system was that the results seen at LSU were repeatable in the field and the system was capable of working with oil-based and water-based fluids, handling high volumes of fluids and cuttings and detecting and following influxes and losses on a real time basis.

With the results of the Petrobras and Chevron wells in hand, various modifications and improvements have been made to the system to increase accuracy and user

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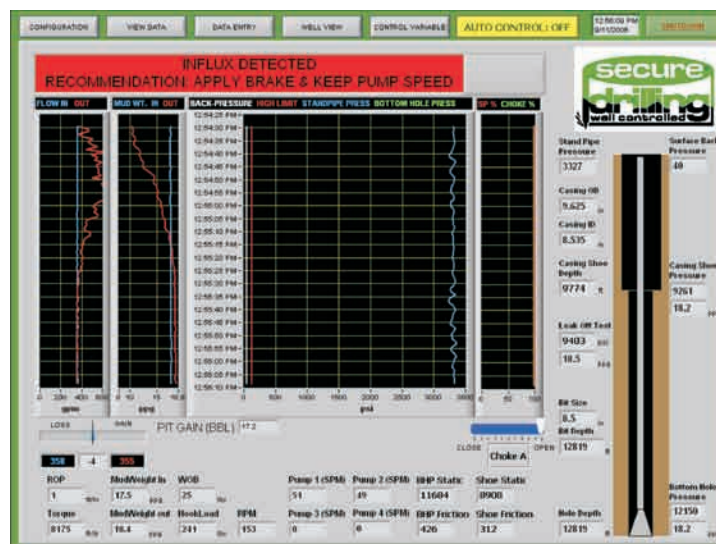


Figure 12 – Continuation of the events described in Fig. 11.

flexibility. The changes to the system have included, several modifications to the screen display to add data and information desired by the drillers, changes to address readings on the system when not drilling, and the addition of a dedicated monitor for the driller and multiple remote panels to increase information flow at the rig. Many of these modifications have already been implemented and used during the second well drilled for Petrobras, from October to December 2006. The response from the rig crew was outstanding. They very quickly realised the benefits the system would bring to their daily operation, not just when the well is a difficult one. The simplicity of the system, small footprint, and by keeping all operational procedures the same as conventional drilling made the rig crew accept the system extremely well.

Another well using the Standard mode and another using the Special MPD mode have already been drilled to date. Results were repeatable and new lessons were also learned. Results from these wells will be presented in future publications.

A series of new wells will be drilled in the coming months, including both modes, Standard and Special. Combination of the MFC with other emerging technologies is also planned for the near future, in an attempt to make the most of the collection of MPD tools available to the drilling engineer.

Conclusions

Drilling the first wells with the MFC provided the following conclusions:

- The system proved to be very accurate, with the confirmation of the possibility of “seeing” the tool joints

passing through the rotating control head while moving the pipe up or down;

- The system confirmed all the capabilities shown during the tests at LSU, this time with cuttings and pipe movement;

- The chokes and flow meter did not have any plugging problems, even drilling the 12 ¼” section with almost 800 GPM and close to 300 ft/hr of ROP;

- The system’s electronics were tested under very warm conditions, and they did not present a problem. The system confirmed it can work under field conditions without problems;

- All the influxes observed during connections were detected in real-time by the system. The influxes were confirmed by the MFC when reaching surface, with the combination of higher flow rate and reduction of density observed from the flow meter;

- All the influxes observed by the system in real-time during connections were only detected by the mud logging one bottoms-up later;

- Surface data collected from the system provides a more realistic picture of the downhole events than the ones provided by PWD, due to the high frequency and accuracy;

- Another interesting event detected by the system was a kick being swabbed in. This confirms the mud weight is very close to the pore pressure, one of the goals of any MPD job. The events detected by the MFC should be

used to manage the mud weight increase along the well, to maintain the mud weight as close as possible to the pore pressure curve;

- The small footprint and simplicity of the system were two of the main points considered by the rig crew as very positive;

- It was confirmed that the Standard MPD mode requires very little training and all operational procedures, including drilling, tripping, connection, casing, logging, cementing, safety and well control do not need to change from the conventional ones. Well design does not need any change either;

- Several suggestions and feed-back were collected from the rig personnel at location from both wells. Some of them have already been implemented for the second well drilled for Petrobras, and were very well received by the rig crew and company man.

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The proven ability of the NuLook™ petrophysical model to find bypassed pay is the backbone of any NuVision study. The NuLook petrophysical analysis utilizes conventional log data (digitizing if necessary), modeling it through an 8-step process, and yields new BVI outputs. The product includes a 6-track output with two distinct flag tracks featuring a 5-flag risk rating system. The NuLook petrophysical services include well-by-well analysis, interpretation, and consultation services that respect all conventional data and utilizes NMR (Nuclear Magnetic Resonance) based outputs including free fluid, bound fluid, and permeability data. These magnetic resonance outputs are simulated from the curve response of conventional log data to produce output similar to what you get from NMR data. The NuLook services identify potential pay intervals; even bypassed zones caused by mineral affected-low resistivity, fine-grained-low contrast-low resistivity, or water salinity problems. With the 2004 introduction of NuLook Textural Vision™, the NuLook processed with a defined minimum data set gives a pore size spectrum, NuSpec™, similar to a T2 distribution from NMR. Through NuTech’s work on advancing Textural Petrophysics, instead of traditional “bulk rock” analysis, a new approach can be utilized which honors the pore

size distribution which forms the reservoir. Differing depositional environments now give rise to the models which are utilized to derive the bound water fraction as well as the permeability associated with the reservoir.

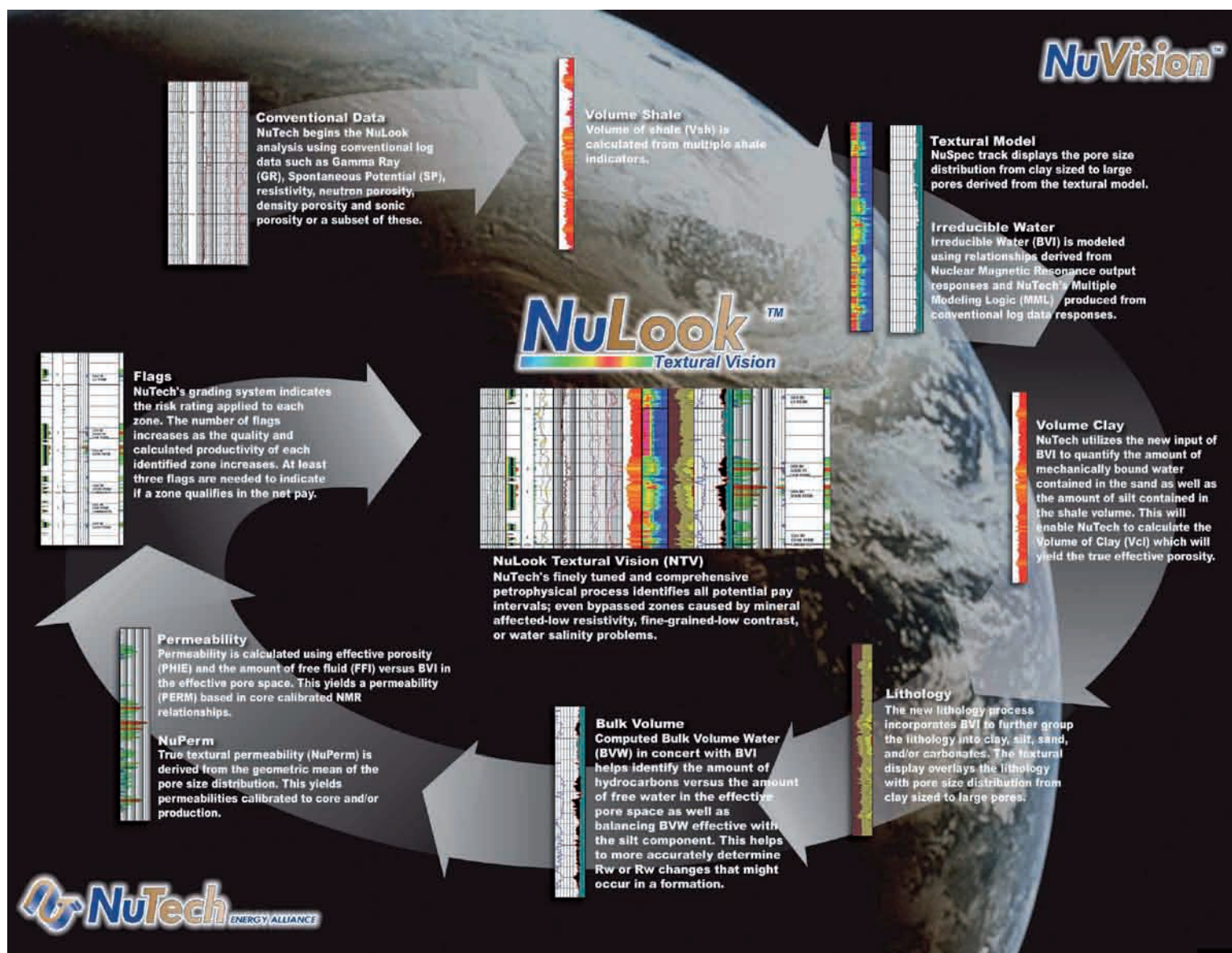
The next steps in the process take advantage of NuStim™, the engineering division of NuTech, normally associated with stimulation design and injection test evaluation. The NuStim engineered completion and optimization process is a perpetually evolving learning cycle which honors all reservoir data to diagnose field specific problems and present unique solutions. By utilizing proprietary, field calibrated relationships, NuStim offers clients a detailed formation depiction that is used to evaluate the completion efficiency of potential oil and gas fields. In NuVision projects, the NuPro “Look Back”™ product is employed to identify reservoir parameters from the analysis of previous completions and matching those parameters to log responses. The NuPro “Look Back” analyses are used to calibrate the NuStim process model for the field, utilizing reservoir properties from logs (NuLook) combined with actual completion and test data for wells to determine if the reservoir is performing to its capabilities and to diagnose well problems. Outputs of

ing of by passed pay

the NuPro “Look Back” include an advanced evaluation of the past completion and an evaluation of the formation characteristics as they relate to the completion and production data. These characteristics include: effective permeability, drainage area, current pore pressure, production summary, EUR, and Net Present Value calculations versus time for the given completion.

Once the NuStim model has been calibrated for the field, either NuStim completion optimizations or NuPro “Look

Forward”™ analyses can be utilized to provide advanced production and reserve estimates for new drill wells or recompletions in the field based on the petrophysical parameters defined in the NuLook product. The NuPro “Look Forward” analysis can incorporate a given completion design provided by the client, or predict the results of a natural completion while the NuStim completion optimization product allows for the comparison of thirty different completion scenarios in an effort to maximize the economic benefit realized by the operator.



The NuLook process is the first step in the NuVision approach to reservoir visualization

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The NuView process is an eight-step process that allows geoscientists and modeling engineers to incorporate all known information such as the well logs and NuLook information, structural framework, seismic attributes, geological depositional environment(s), and well production performance into one integrated 3D reservoir model.

NuView 3D Reservoir Vision™ incorporates all the benefits of NuLook's proprietary textural attributes into a 3D field-wide presentation. Considering multiple wells and NuLook results within a field represent another piece of the bigger picture. From this perspective, another proprietary program and process emerge, NuView 3D Reservoir Vision. NuView takes multiple sources of information that have been collected on a well by well basis and analyzed via the NuLook process, incorporating these with advanced geological modeling and proprietary workflow processes, to obtain a best understanding of reservoirs, reservoir performance, and bypassed pay opportunities.

The NuView workflow combines all known information about the reservoir and distributes the NuLook properties within a geological interpretation using a variety of techniques applicable for the particular depositional setting. By understanding the pore size and permeability relationships at each well, it is now possible to fill in the intra well and surrounding area to best understand how the properties vary not just throughout each well, but throughout the entire field. This level of modeling allows operators to identify previously unswept regions of the reservoir as well as to select optimal drilling targets and pay opportunities.

The NuView process is an eight-step process that allows geoscientists and modeling engineers to incorporate all known information such as the well logs and NuLook information, structural framework, seismic attributes, geological depositional environment(s), and well production performance into one integrated 3D reservoir model. With this model, the geologist and engineer are taken from a single well vantage point to an all encompassing understanding of how all the data and interpretation fit together, why the reservoir responded historically as it has and how it will perform in the future. Each step is very controlled so that the petrophysical attributes make sense in the same way that the original log data made sense once the NuLook process was completed. Then an innovative approach termed Composite Stratigraphic Image Mapping (CSIM), is created to combine multiple realizations into a single view to build confidence in the reservoir model and to minimize uncertainty and risk.

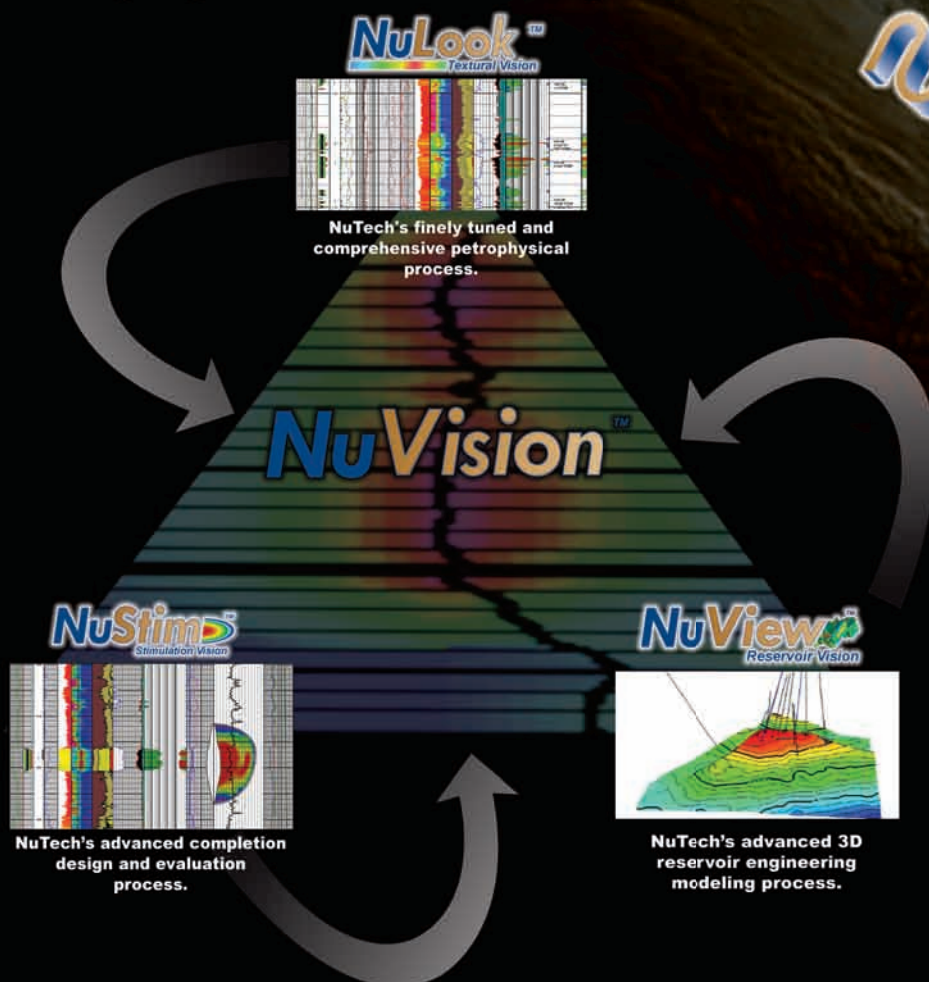
The CSIM approach is analogous to having 25 experts analyze and map the same data, determine the probability of having favorable reservoir properties and geological features, then create a set of facies, property and hydrocarbon maps that they all agree with. The entire process is controlled by the appropriate geological depositional system or environment. This innovative new approach may transform how the industry views reservoir models.

The result is a mathematically balanced structural interpretation with stratigraphy to obtain a more precise correlation. In addition, lithologic, stratigraphic and structural anomalies or discontinuities are better defined. Ultimately, the spatial relationships within a field are much better understood, and this, in turn, leads to better understanding of both well and field performance. The NuView service utilizes the unique textural information of the NuLook petrophysical analysis, seismic, and other geologic inputs to render field wide 3 dimensional models of the structure, the reservoir, and associated stratigraphic variance. NuView uses advanced 3D geological modeling techniques, with uncertainty and risk analysis, to provide clients with a better understanding of their rock property distribution, inter-well permeability connections, and hydrocarbon volume calculations. By

populating the NuView grid with inputs from the NuLook logs, the NuView product can add a textural display to the client's reservoir picture. This textural image can move a client from traditional maps of porosity and structure based on conventional log evaluation and seismic surveys to maps of free hydrocarbon saturation and reservoir permeability. These maps allow the operator to explore the areas of both improved reservoir quality and un-drained hydrocarbons within the field.

The primary purposes of the NuVision process are to determine the extent and volumes of bypassed pay, develop optimal in-field drilling plans based and lower the risks of field development going forward with a great degree of certainty and detail and to optimize the recovery of assets from each field. ⬇

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The NuVision approach consists of three proprietary processes used to identify and quantify hydrocarbons that have historically been bypassed in existing fields. NuVision uses textural petrophysical attributes to enhance the understanding of reservoir quality and connectivity, the depositional environment and facies distribution across the field, and to ultimately demonstrate how to best produce those hydrocarbons either through low cost recompletions, re-drills, or new drill wells.

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Free Standing Hybrid Water Depth

Francisco E. Roveri, Petrobras Research & Development Center - CENPES, Paulo Ricardo F. Pessoa, Petrobras Subsea Engineering Services - E&P - SERV and Francisco Henrique, Petrobras

The oil exportation of the P52 semi-submersible platform, located in the Roncador field in 1800 meters water depth is designed to utilize an 18 inch OD FSHR (Free Standing Hybrid Riser). This alternative was developed through a FEED (Front End Engineering Design) contracted to 2H Offshore, according to technical specifications and functional requirements provided by Petrobras. Flow assurance studies require 50 mm thermal insulation material for the vertical portion of the riser.



The high expected production rates of the P52 platform require an 18 inch oil export pipeline. The instrumented pigging requirements dictate the export riser to have the same diameter. This large bore specification combined with the deep water site put this application outside the present feasibility range of solutions such as flexible pipes and steel catenary risers (SCRs). Both these solutions present high top tension loads for installation and operation. The lateral buckling failure mode in flexible pipes and the fatigue damage in the touch down zone (TDZ) of SCRs are further design limitations currently only solved by the use of heavier pipes which further compromise hangoff loads in a negative design spiral.

The FSHR system has a reduced dynamic response, as a result of significant motion decoupling between the Floating Production Unit (FPU) and the vertical portion of the FSHR system and its vessel interface loads are small when compared with SCRs or flexible pipe solutions. Therefore it is an attractive alternative solution for this kind of application. There are further cost savings

associated with this concept due to the added advantage of having the riser in place prior to the installation of the FPU.

The hybrid riser concept, which combines rigid (steel) pipes with flexible pipes has been utilized by the offshore industry since the 80s. The Riser Tower first installed by Placid Oil [1] at Gulf of Mexico in Green Canyon 29 was refurbished and re-utilized by Enserch. More recently, the concept underwent some changes for application at Girassol field [2] in Angola, where three towers were installed by TFE. Other reference papers are [3], [4] and [5].

The Riser Towers at Girassol field are positioned with an offset with regard to the FPU, whereas at GC29 the vertical portion of the riser was installed by the FPU and was located underneath the derrick.

Petrobras has been studying the hybrid riser concept for some years. Five years ago this alternative was considered

Rigid Riser for 1800m

Two years ago Petrobras contracted 2H to provide the feasibility studies of an export oil FSHR to be utilized at P40. Due to changes in field development planning, the study was further developed for the P51 and P52 semi-submersible platforms.

for conceptual studies at Albacora Leste field, in 1290 meters water depth, for the P50 turret moored FPSO. Two alternatives were considered for comparison: a Steel Lazy Wave Riser (SLWR) and one concept combining rigid and flexible pipes.

In 2003 Petrobras contracted the conceptual study development of the Riser Tower solution for the starboard side 8 inch production lines of the P52 semi-submersible platform.

Two towers were considered, each one comprising seven production lines and one spare line.

Five water and gas injection monobore FSHRs (10 to 12 inches) have recently been installed in West Africa offshore Angola, at Kizomba field in about 1200 meters water depth. The design of these risers has some key differences to the concept presented in this paper, each of which offers different design and operational advantages.

Two years ago Petrobras contracted 2H to provide the feasibility studies of an export oil FSHR to be utilized at P40. Due to changes in field development planning, the study was further developed for the P51 and P52 semi-submersible platforms.

System Description

The FSHR design may have a number of variants. The one described below is the base case considered for P52 oil export riser to be installed from a MODU due to the availability of such vessels already under contract at Campos Basin. The required design life is 25 years.

The FSHR consists of a single near vertical steel pipe connected to a foundation system at the mud line region. The riser is tensioned by means of a buoyancy can,

which is mechanically connected to the top of the vertical pipe. The riser pipe passes through the central stem of the buoyancy can, which is located below the sea level, therefore beyond the zone of influence of wave and high current. A gooseneck assembly is located on top of the buoyancy can. A flexible jumper links the gooseneck to the FPU and significantly decouples the vertical part of the FSHR from the vessel motions.

The foundation may typically be offset from the FPU by more than 200 meters, depending on the optimization study, which takes into consideration the following parameters: (a) flexible jumper length, (b) riser base offset, (c) buoyancy can depth, (d) net upthrust provided by the buoyancy can and (e) the azimuth of the FSHR system.

The FSHR goes from the #1 hangoff slot at P52 to the Pipeline End Termination (PLET) located near the riser base. The lower end of the vertical part interfaces with a stress joint. Below the stress joint there is the offtake spool, which connects to the foundation by means of a hydraulic connector. A rigid base jumper connects the mandrels located at the offtake spool and PLET, providing the link between the FSHR and the pipeline. The foundation pile will be drilled and grouted.

The tension is given by the upthrust provided by the nitrogen filled buoyancy can located on top of the vertical pipe. The vertical pipe shall be kept always in tension in order to keep the FSHR stable for all the load cases.

The riser pipe passes through a inner 36 inches OD stem within the buoyancy can, and is guided within the stem by centralizers. Where the riser pipe is subject to high bending loads such as the keel ball centralizer on the buoyancy can, taper joints are used to reduce the stress in the riser pipe. The buoyancy can is secured to the riser

pipe at the top of the can by means of a bolted connection.

At the top of the free-standing riser is the gooseneck assembly. This assembly consists primarily of the gooseneck and an ROV actuated hydraulic connector which allows the gooseneck and flexible jumper to be installed separately from the vertical section of the riser. The gooseneck assembly also includes a cross-brace tied to a support spool in order to provide support against the loading applied to the gooseneck from the flexible jumper. Attached to the gooseneck is the flexible jumper. The flexible jumper connects the freestanding section of the riser system to the vessel, and includes bend stiffeners to ensure that the range of rotations experienced at the end connections do not damage the jumper due to low radius of curvature. The flexible jumper has enough compliance such that the vessel motions and offsets are substantially decoupled from the vertical portion of the FSHR system, and consequently the wave-induced dynamic response of the free standing riser is low.

Differences from existing design

The position of the gooseneck in relation to the buoyancy can is the main difference between the West African and P52 FSHR designs. In the earlier design, the gooseneck is positioned below the buoyancy can and the vertical riser is tensioned by the can via a flexible linkage or chain.

This arrangement simplifies the interface between the buoyancy can and vertical riser, and allows pre-assembly of the flexible jumper to the gooseneck before deployment of the vertical riser. However, in the event of flex-

ible jumper replacement or repair, an elaborate jumper disconnection system needs to be employed below the buoyancy can.

Positioning the gooseneck at the top of the buoyancy can allows for independent installation of vertical riser and flexible jumper. A flexible pipe installation vessel can install the flexible jumper at a time of convenience. This minimizes the risk of damage to the flexible jumper during installation as the procedure is similar to that of a shallow water flexible riser with the first end at the top of the buoyancy can. This design also facilitates and minimizes the time for flexible jumper retrieval in case of damage, in service, to any of its components such as stiffener, end-fittings or pipe outer sheath.

On the other hand, it is necessary to have a continual vertical riser string right through the centre of the buoyancy can to provide a connection hub for the flexible jumper at the top. This arrangement introduces interfaces between the riser string and buoyancy can which have to be carefully analyzed and engineered. In addition, installation analysis has also to be conducted to assess the loads on the riser string during deployment through the buoyancy can.

Other differences are the foundation type (suction piles x drilled and grouted pile) and bottom interface (flexjoint x tapered stress joint).

Characteristics of Components

The main characteristics of the FSHR system are presented in table 1 below.

Foundation/FPU offset	360 m
Depth of buoyancy can	175 m
Length of flexible jumper	425 m
Flexible jumper azimuth (from N)	339.7°
Base tension - in service (oil filled)	200 Te
Base tension - stand-by (water filled)	189 Te
Hang-off angle at FSHR side	40.2°
Hang-off angle at FPU side	15.6°
Leaning towards FPU, neutral condition	85m
FSHR angle w.r.t. vertical, neutral cond.	3°
Oil mass density	841 kg/m ³
Pipe minimum radius of curvature	3D

External diameter	5.5 m
Thickness	5/8 in
Total length	36.5 m
Central stem pipe	36x1 in
Number of compartments	16
No. of contingency compartments	1 or 2
Length of each compartment	2.143 m
Mass in air	205 ± 12 Te
Maximum upthrust	565 Te
In-service upthrust	514 Te

Table 1 - FSHR main characteristics.

The vertical part of the FSHR is an assembly of standard joints and special joints, such as the stress joints at the bottom and top interfaces. The main characteristics of the standard joints are presented at table 2 below.

External diameter	18 in
Thickness	5/8 in
Material	X65
Thermal insulation thickness	50 mm PP
Density of insulation material	910 kg/m ³
Corrosion allowance	3 mm

Table 2 - Characteristics of the standard joint.

The main characteristics of the flexible jumper are presented in table 3.

Weight in air, empty	305 kgf/m
Weight in water, empty	93 kgf/m
External diameter	0.5132 m
Internal diameter	16 in
Bending stiffness	133.41 kNm ²
Axial stiffness	750263 kN
Torsional stiffness	20505 kNm ²
Length of bending stiffness	5.5 m

Table 3 - Characteristics of flexible jumper

Components of the Lower Riser Assembly

The lower part of the FSHR is located above the foundation and consists of three components: the offtake spool, the lower taper joint and the lower adapter joint. The assembly interfaces with the seabed foundation at the bottom and the lower cross-over.

Offtake spool

The offtake spool is a cylindrical component approximately 1.80m tall and 1.04m external, cast from 50ksi steel. The spool contains a flow path that travels through the top of the spool and exits from the side via an offtake. The offtake, formed as an induction bend that exists from the side of the spool, presents an upward facing mandrel for connection of the rigid base jumper. A weld on the compact flange connects the offtake to the side of the spool.

The offtake spool has a studded bottom for interface with the base connector and a studded top for interface with the lower taper joint.

Lower taper joint

The lower taper joint is a forged component fabricated from 80ksi yield strength material. This is a high specification component designed to control the bending at the base of the riser.

It is a 10.4m long component with a linearly decreasing wall thickness and its profile is optimized to withstand both extreme loads and long term fatigue loading. The upper end is connected to the lower end of the lower adapter joint via a weld on compact flange connection.

Lower Adapter Joint

The lower adapter joint is a 28.5m long section with 31.8mm wall thickness. The pipe is fabricated from a 65 ksi grade material, from two standard pipe sections welded together and a shorter pipe section to achieve the required length. Welded to the top is a seafastening collar which is used during transportation and installation.

Its function is to provide an interface and stiffness transition between the lower taper joint and the standard riser line pipe joints. Its length is such that it facilitates pre-assembly of the components to the buoyancy can for transportation offshore. Weld on compact flanges connections are utilized at both extremities.

Riser line pipe

A special joint called a lower cross-over joint is located just above the lower adapter joint and forms the connection between the lower riser assembly and the standard riser line pipe joints.

Lower cross-over joint

The lower cross-over joint consists of 12.2m joint of standard riser pipe with 15.9mm wall thickness. At the lower end there is a weld on the profile. At the upper end of the joint is a handling collar with a weld profile above it to enable the joint to be welded to the standard riser line pipe.

Standard joints

The riser line pipe consists of approximately 58 double riser joints of 18inch outer diameter and 15.9mm wall thickness. It is specified as 65 ksi grade steel. Each double joint has a handling collar welded at the top of the joint to allow it to be handled using standard or adapted casing handling tools. The double joint length including the handling collar is 25.9m.

Bouyancy can taper joint assembly

At the top of the riser line pipe string is the buoyancy can taper joint assembly. The assembly consists of the upper

The lower part of the FSHR is located above the foundation and consists of three components: the offtake spool, the lower taper joint and the lower adapter joint. The assembly interfaces with the seabed foundation at the bottom and the lower cross-over.

adapter joint, upper adapter extension joint, buoyancy can lower taper joint, buoyancy can adapter joint and buoyancy can upper taper joint. This region is subjected to high bending moments due to the interaction of the riser with the buoyancy can, and thus a stiffened length is required to control the stresses during extreme and fatigue loads.

Upper Adaptor Joint

The upper adapter joint is as the transition between the standard riser line pipe and the thickened pipe used in the taper joint assembly. It consists of two joints of pipe fabricated from a 65ksi grade steel.

Upper Adaptor Extension Joint

The upper adapter extension joint is a 10.5m long forged component with an integral compact flange at the upper end, and a weld on compact flange at the lower end. The joint is located between the upper adapter joint and the buoyancy can lower taper joint, which is a critical location for both extreme stress and fatigue loading. It is fabricated from 80ksi yield strength material.

Buoyancy Can Lower Taper Joint

The buoyancy can lower taper joint is a forged component fabricated from a material with 80ksi yield strength. The joint is 10.8m in length and includes a double taper profile and a shoulder for the keel ball located at the centre of the joint. The taper profiles are both linear. At the centre of the joint is the keel ball. The keel ball interfaces with the buoyancy can central stem to provide centralization of the riser as it enters the bottom of the buoyancy can stem. The keel ball consists of a solid ring, which is located on the buoyancy can lower taper joint above the shoulder.

Buoyancy Can Adapter Joint

The buoyancy can adapter joint is located within the buoyancy can, and connects the buoyancy can lower taper joint to the buoyancy can upper taper joint. The adapter joint consists of two sections of special riser line pipe with 19" outer diameter and 31.8mm wall thick-

ness, manufactured from a 65 ksi grade steel. Its length is 23.58m. Both ends of the joint are fitted with weld-on compact flange connections, which also act as the location point for centralisers for controlling the curvature of the riser within the extension of the buoyancy can. There are thus four contact points between the riser string with the buoyancy can stem: one at the top, two intermediate and one at the keel ball. The last three provide only horizontal restraint whereas the first cause the riser and buoyancy can to have the same linear and angular displacements in the three directions.

Buoyancy Can Upper Taper Joint

The buoyancy can upper taper joint is a forged component located at the top of the riser string, between the buoyancy can adapter joint and the gooseneck. The joint is fabricated from 80ksi yield strength steel and its length is 7.7m. At the top of the tapered section of the joint is a load shoulder with a flange profile, to which the load monitoring spool is bolted. The load monitoring spool in turn connects the load shoulder on the top of the buoyancy can. This provides the connection between the buoyancy can and the riser string.

At the top of the buoyancy can upper taper joint is a 16-3/4" 10ksi connector mandrel, to which the gooseneck connector is attached.

Load Monitoring Spool

The load monitoring spool (LMS) consists of a 1.1m long joint, with 38inch OD and 1inch wall thickness, fabricated from 65ksi grade line pipe. It has flange connections at both ends. The spool is located between the buoyancy can top and the buoyancy can upper taper joint. Its function is to transfer the upthrust generated by the buoyancy can into the riser string.

The spool will be fitted with load measuring sensors in order to monitor the integrity of the riser system. The monitored forces will be transmitted to the production platform.

The base case installation procedure is defined such that the FSHR can be installed using the P23 MODU. The procedure requires the buoyancy can to be transported to the work site separately from the riser, then positioned beneath the drilling rig.

The upthrust is transmitted by the buoyancy can to the load monitoring spool base. The spool is compressed and transmits the load to a shoulder located at top of the buoyancy can upper taper joint. The load is then transmitted to the riser string, which will be in tension, providing then stability to the system.

Buoyancy Can Assembly

The vertical section of the riser system is tensioned utilizing a nitrogen filled buoyancy can. The can is a cylindrical design, 36.5m in length and 5.5m in diameter, fabricated from 50ksi yield material. It contains 16 compartments, each of 2.14m in height, separated by bulkheads. The buoyancy can is designed to be pressure balanced, with the internal pressure slightly above the external pressure of water. This approach resulted in the thickness of the buoyancy can to be 5/8inch.

Running along the longitudinal axis is a 36inch outer diameter central stem, with a 1inch wall thickness, through which the riser string passes.

At the bottom of the buoyancy can, a 2.25m long keel extension is fitted which consists of a continuation of the 36" stem pipe. The keel ball on the buoyancy can lower taper joint reacts against the keel extension, which is fitted with an oil impregnated bronze liner to reduce wear. The buoyancy can is connected to the riser via a load shoulder located at the buoyancy can upper taper joint, to which the load monitoring spool is attached. The bottom of the load monitoring spool is positively connected to the top of the buoyancy can by bolts.

The buoyancy can is de-watered by means of ports located on the side of each compartment. Each compartment features an inlet and an outlet port. During de-watering nitrogen is injected into the can at pressure and the buoyancy can compartment is slightly overpressurized with regard to the water pressure outside.

The buoyancy can design is such that at least one of the 16 compartment is maintained permanently water filled

as a contingency. Should one compartment fail in service, a contingency compartment can be de-watered in order to keep the operational tension in the riser string.

The difference between the internal and external pressures corresponds to the length of each compartment.

Gooseneck assembly

The components located at the upper part of the system are described hereinafter.

Hydraulic Connector

A 16-3/4inch-10ksi hydraulic connector is utilized to attach the gooseneck to the riser string. The connector is hydraulically locked, and actuated via an ROV stab. The role of the connector is to allow the flexible jumper to be retrieved during service should the jumper be required to be fixed or replaced.

Gooseneck

At the top of the system is the gooseneck, which provides the change from the vertical section to the flexible jumper to the production platform. The gooseneck is a curved pipe, formed using induction bending with a 3D minimum bend radius. The lower end of the gooseneck is attached to the gooseneck support spool, which in turn is connected to the API flange on the connector.

Gooseneck support

The gooseneck is braced by a structural beam which connects between the upper end of the gooseneck and the gooseneck support spool at the lower end of the gooseneck. The support brace and support spool provide a load path for the loading applied to the riser from the flexible jumper, and prevent overstressing of the gooseneck.

Flexible Jumper Assembly

The flexible jumper assembly consists of the flexible jumper, end terminations and bend stiffeners at both the FSHR end and the production platform end of the jumper.

Flexible Jumper

The flexible jumper has a 16 inch internal diameter, is 425 meters long and rated for 3000 psi design pressure and 90°C design temperature.

End Terminations

At both ends of the flexible jumper are end termination assemblies as specified by the flexible jumper manufacturer. At both ends of the jumper the termination is required to interface with a compact flange connection.

Bend Stiffeners

Bend stiffeners are located at both ends of the flexible jumper. Each stiffener is designed to meet the predicted range of jumper rotations at both the gooseneck attachment and at the production platform connection. The bend stiffeners are designed and manufactured according to the details specified by the flexible jumper manufacturer.

Installation

The base case installation procedure is defined such that the FSHR can be installed using the P23 MODU. The procedure requires the buoyancy can to be transported to the work site separately from the riser, then positioned beneath the drilling rig. The riser is installed by continually joining and running the riser through the buoyancy can. Once fully assembled, the entire riser is then lowered to the seabed using drill collars and connected to the foundation. Some steps of the installation procedure are shown hereinafter.

Firstly some components of the lower part (hydraulic connector, offtake spool, lower taper joint and lower adaptor joint) are assembled to the buoyancy can.

Buoyancy can lifting onto barge

The buoyancy can is lifted from the yard by a crane and positioned onto the barge. After that a seafastening is provided in order to resist the barge motions during transportation to site.

Transportation of the buoyancy can

The buoyancy can and the pre-installed lower riser assembly within the buoyancy can stem are transported to the site of deployment.

Transfer of the buoyancy can to the water

At the proximities of the production platform, the buoyancy can and lower riser assembly are transferred from the transportation barge to the water, by a controlled flooding of the barge and sliding the buoyancy can. At this state, a wire rope connects the top of buoyancy can to the derrick of the MODU.

Transfer of the buoyancy can to the MODU

After separation of the transportation barge, the uprighting of the buoyancy can is initiated, by means of a controlled flooding of some compartments. At this stage the buoyancy can has 4 compartments nitrogen filled, thus having overall negative buoyancy. The keel hauling process is then initiated, and the weight of the buoyancy can is transferred gradually to the derrick of the MODU.

Buoyancy can beneath the MODU

At the end of the keel hauling process, the buoyancy can will be beneath the MODU derrick, still supported by the wire rope connected to the platform.

Buoyancy can supported by tensioners

After that the buoyancy can is lifted until its upper end is approximately 0.5m below the Lower Deck of the MODU and its weight is transferred from the keel hauling wire rope to the MODU drilling riser tensioning system.

Lowering of riser joints

The procedure for deploying the riser joints is shown hereinafter.

Lower Cross Over connection

The Lower Cross Over Joint is the first connection to be made to the pre-installed components of the FSHR system within the stem of the buoyancy can. After the connection is made, the seafastening collar at the top of the buoyancy can is removed.

Lowering of the Lower Cross Over Joint and first Standard joint

After the first connection aforementioned is made, the Lower Cross Over and the first Standard joints are deployed, such as the lower extremity of the string is approximately 40 meters below the buoyancy can lower end.

Lowering of the buoyancy can for deployment of the remaining joints

The buoyancy can is then lowered until its upper end is placed at the pontoon deck level. The buoyancy can is lowered by supporting the can on four padeyes on short chains, then transferring the load to the remaining four

The remaining standard riser joints are welded at the drill floor and run through the buoyancy can. The riser is allowed to water fill during deployment.

The design of an FSHR typically involves an upfront global analysis of the system to optimize the riser configuration. Parameters to be varied are offset from the production platform, depth of buoyancy can, flexible jumper length and net upthrust provided by the buoyancy can.

chains with longer chains using the full stroke range of the tensioners. Extension chains are then added to the 4 tensioners with shorter chains such that all eight tensioners are used. The buoyancy can upper end is connected by horizontal wire ropes to pulleys located in strong points at the pontoon level and to winches at the deck, such as to control the horizontal motions of the can.

The remaining standard riser joints are welded at the drill floor and run through the buoyancy can. The riser is allowed to water fill during deployment.

Lowering of the Buoyancy Can Upper Taper Joint to the top of the buoyancy can

Once all standard riser joints are welded together, the upper riser joints consisting of the upper adapter joint, the upper adapter extension joint, the buoyancy can lower taper joint, the buoyancy can adapter joint and the buoyancy can upper taper joint are run. These joints are made-up using flange connections. A riser running string is then attached to the connector mandrel profile at the top of the buoyancy can upper taper joint, and the riser string is lowered through the drill floor and lowered to the top of the buoyancy can.

Lifting of the buoyancy can and riser string

Both the buoyancy can and the riser string are then raised together to the level of the moonpool, where the riser string is landed on the top of the buoyancy can with a small landing weight. The flange connection between the load monitoring spool (attached to the upper taper joint), and the buoyancy can is made up, and thus a fixed connection between the riser and the buoyancy can is made.

Lowering of the riser string and buoyancy can

The lateral restraint wire ropes are removed and the buoyancy can is released from the drilling riser tensioning system. The riser string and buoyancy can assembly is then lowered by using drill collars.

Riser string close to stab-in

During the lowering process, nitrogen is pumped under pressure into the top 4 compartments of the buoyancy can via a temporary manifold system to prevent them from filling with water. Prior to landing, a further 2 compartments are de-watered to reduce the net weight of the riser system to allow it to be landed using the motion compensator.

Riser landed on the foundation pile and locked down

The bottom of the riser is landed on the foundation pile, the orientation is set by a helix to ensure that the lower offtake is in correct alignment with the PLET, and the FSHR is locked down using an ROV.

After lock down of the hydraulic connector, it is necessary to tension the string by means of the drill collar, with two objectives: to test the hydraulic connector and to provide stability to the system, before initiating de-watering of the buoyancy can.

De-watering of the buoyancy can

After lock down of the hydraulic connector, the stability of the system is partly due to the tension applied by the drill collar string. The ROV starts the de-watering process of the buoyancy can compartments by means of injecting nitrogen. As long as the de-watering proceeds, the tension applied by the MODU is decreased, such as to keep the resulting tension approximately constant. At the end of the process, the tension provided by the buoyancy can allows the riser to free-stand and the drill collar string is disconnected from the top of the buoyancy can.

After conclusion of this process the flexible jumper is installed. The installation of the vertical section of the FSHR may take place before arrival of the production platform.

A typical plot of the wave fatigue life along the riser length shows that the damage is very low, however hot spots do occur at certain critical locations.

Connection of the gooseneck to the mandrel at riser top

The gooseneck attached to the flexible jumper end at the buoyancy can side is deployed by a Laying Support Vessel (LSV) and connected to the mandrel of the Buoyancy Can Upper Taper Joint. An ROV actuates a hydraulic connector.

LSV installing the flexible jumper

The gooseneck and flexible jumper are first attached to the riser using the LSV, and the flexible jumper then unreeled and pulled-in to the slot on the P52 platform.

Design Approach

The design of an FSHR typically involves an upfront global analysis of the system to optimize the riser configuration. Parameters to be varied are offset from the production platform, depth of buoyancy can, flexible jumper length and net upthrust provided by the buoyancy can. Clearance maybe an issue and interference with adjacent risers or mooring lines drives the choice of the system layout. Following the selection of the system configuration, global storm and fatigue analyses are conducted to define the functional loadings on the critical riser components as well as Stress Concentration Factors (SCFs) requirements.

The FSHR comprises special components, such as taper joints, gooseneck, offtake spool and rigid base jumper, for which detailing will be required. In addition, the riser string components shall be able to withstand both the installation and in-place loads.

The FSHR benefits from the fact that the overall system design is robust and relatively insensitive to a number of parameters. Therefore, a relatively conservative design approach may be adopted for the upfront global riser design, with allowances for parameter sensitivities and design changes during design completion.

The system is designed and analyzed in accordance to API RP 2RD.

Riser Response and Design Drivers

Extreme Storm

As the riser and buoyancy can are located away from the wave zone and surface current region, the direct wave loading on the system is low. The flexible jumper connecting the vertical section of the riser to the production platform significantly decouples the riser motions from the vessel excursions and first order motions.

The riser response is driven largely by current and vessel offset, which causes an increase in loading in the gooseneck and also at the riser lower end. However this can be solved by local strengthening of the components. Another critical region is where the riser exits the base of the buoyancy can and a taper joint is required to withstand the interface loads.

At both ends of the flexible jumper, bend stiffeners are necessary to keep the curvatures in the flexible pipe within plots of typical bending moments. Distribution along the riser length under extreme storm shows two peaks, one at the riser base and the other at the interface with the base of the buoyancy can.

Along the majority of the riser string, the relationship between the combined Von Mises stress and the material yield strength shows a gradual linear increase towards the top of the riser, which is mainly due to axial tension and hoop stress in the pipe. At both ends of the riser however bending loads are present in the system, but are faced using special components such as taper joints, which control the curvature and stresses. Due to this, the stress ratios at the top assembly are lower than at the riser line pipe, in spite of higher effective tension and bending moments near the buoyancy can.

Along the vertical section of the FSHR, the stresses are practically static, barely affected by quasi-static loads (vessel static offsets and current) or dynamic loads (direct wave load and first and second order motions). The design of deeper components, such as the lower taper joint, is driven by quasi-static loads. The upper riser

The installation phase is a critical issue for the design of the FSHR, mainly due to utilization of a MODU for deployment. The operating window is narrowed due to buoyancy can motions at the moonpool region, caused by the action of current and waves, and the resulting riser forces at the interfaces with both the buoyancy can bottom and rotary table.

component designs are dictated by both quasi-static and dynamic loads.

Wave fatigue

The long term dynamic wave loading on the system is very low. The majority of the riser dynamic motion is associated with the second order drift motions of the vessel, which gradually alter the configuration of the flexible jumper and consequently the loading on the vertical section of the FSHR.

A typical plot of the wave fatigue life along the riser length shows that the damage is very low, however hot spots do occur at certain critical locations. These locations are at the lower taper joint, and at the bottom of the buoyancy can. Some precautions have to be taken in order to achieve the required damage limit at these locations, by sometimes refining the locally thickened joint designs. It is necessary that welds are either avoided or high quality welds are utilized, and that stress concentration factors are minimized in these regions.

Vortex Induced Vibrations (VIV)

The VIV response of an FSHR generates fatigue damage that is low along the majority of the riser length, but high at the two ends of the vertical section of the system. The critical region for VIV damage tends to occur in the riser string just below the buoyancy can interface. Shear7 was utilized for assessment of fatigue damage due to VIV.

It is necessary to design the components at the locations of peak fatigue damage such that they are capable of withstanding the predicted stress cycling. Generally, locally thickened components can be designed, or refined, to give adequate fatigue performance. The use of strakes is not necessary.

Installation and In-Place Fatigue of the FSHR system

The fatigue damage the system may undergo during installation shall be limited such as to leave most of the

allowable damage to be spent when the riser is in-place. The installation analysis, mainly for the situation when the buoyancy can is at the moonpool region of the MODU, will assess the riser damage due to the MODU first order motions and from VIV.

Considering a safety factor of 10, the required system fatigue life is 250 years, which is fulfilled for the in-place condition. The in-place analyses have assessed the damage due to first and second order motions and due to VIV. The acceptance criterion establishes that the three sources of damage be added and that the resulting fatigue life be above 250 years. Most of the damage is due to VIV, followed by first order motions. The damage due to second order motions is negligible.

Assessment of VIV Damage by CFD

In addition to the assessment of fatigue damage due to VIV by using Shear7, the damage is being assessed by the utilization of the Computational Fluid Dynamics (CFD) methodology. Petrobras contracted the University of São Paulo to perform such studies. In this method, a finite element structural model based on the Euler-Bernoulli beam theory is employed to calculate the dynamic response of the cylinder. A general equation of motion is solved through a numerical integration scheme in the time domain. Firstly, a static solution is found for the riser. Then, in the dynamic analysis, the stiffness matrix obtained from the static analysis is used as an average approximation. A lumped approach is employed. A mass lumped matrix is constructed and the damping matrix is evaluated in a global manner.

The method utilized is the Discrete Vortex Method (DVM), which is a Lagrangian numerical scheme technique for simulating two-dimensional, incompressible and viscous fluid flow. The method employs the stream function-based boundary integral method and incorporates the growing core size or core spread method in order to model the diffusion of vorticity. In the DVM the body is discretized in N_w panels, and N_w discrete vortices with circulation are created from a certain dis-

For engineering, procurement and construction (EPC) contractors not having a suitable vessel, or unable to mobilize their vessels to install the FSHR, the ability to use a MODU as the installation vessel could prove to be an attractive alternative.

tance of the body, one for each panel. These vortices are convected and their velocities are assessed through the sum of the free stream velocity and the induced velocity from the other vortices. The induced velocities are calculated through the Biot-Savart law. Forces on the body are calculated integrating the pressures and viscous stresses. Viscous stresses are evaluated from the velocities in the near-wall region, and the pressure distribution is calculated relating the vorticity flux on the wall to the generation of circulation.

Model Test

The installation phase is a critical issue for the design of the FSHR, mainly due to utilization of a MODU for deployment. The operating window is narrowed due to buoyancy can motions at the moonpool region, caused by the action of current and waves, and the resulting riser forces at the interfaces with both the buoyancy can bottom and rotary table.

Results from numerical analysis assessment show that the allowable sea states for some stages of the deployment are significantly milder when compared to the weather window of previous deployments of subsea hardware, such as manifolds, already performed by Petrobras utilizing MODU.

Modeling the entire FSHR system in 1800 m water depth would require a very small scale (approximately 1:180) and some important effects could not be well represented. Therefore it was decided to test the system behavior only during installation. A model test at the scale of 1:28.7 representing the buoyancy can, MODU and riser string was constructed and tested at Marintek. The objective was to corroborate the results of numerical calculations.

Three phases were simulated: (a) buoyancy can free floating, (b) keel hauling of the buoyancy can and (c) buoyancy can at the moonpool region, suspended either by wire rope at the derrick or by the drilling riser tensioning

system, and the riser string passing through the stem. Two riser lengths were considered: initial and total length. For the last, it was necessary to truncate the riser string.

Conclusions

In the FSHR design concept, the location of the buoyancy can below high current and wave zone, and the use of the flexible jumper to significantly decouple vessel motions from the vertical riser greatly reduces the system dynamic response, resulting in a robust riser design particularly suited to deep water applications.

The design is relatively insensitive to severe environmental loading and non-heave optimized host vessels when compared to SCRs and flexible risers. The robustness allows the riser to be conservatively analysed, and allowances for design changes and uncertainties to be included upfront in the design process, thus giving greater confidence in the overall system design.

For engineering, procurement and construction (EPC) contractors not having a suitable vessel, or unable to mobilize their vessels to install the FSHR, the ability to use a MODU as the installation vessel could prove to be an attractive alternative.

It can be said that the FSHR concept extends the reach of deep water riser feasibility as it avoids the main technical problems faced by the other solutions, and arguably, it may be the only proven riser concept feasible for deep water large bore applications.

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RECRUITMENT

ROV Engineer in Brazil

The Engineer will have technical responsibilities in the execution of projects undertaken. He/she will contribute to a multi-discipline project team. These projects vary from engineering, procurement, manufacture and test projects, to engineering projects in support of ROV and/or construction engineering activities.

DUTIES & RESPONSIBILITIES

- Understanding of, and ability to co-ordinate other engineering disciplines
- Health, Safety, Environmental and Quality awareness
- Understanding of the practical aspects of design with regards to manufacture and operation
- Able to mentor and provide technical support to graduates and project engineers
- Technically responsible for mechanical engineering aspects of projects
- Budgetary planning
- Technical contact with Oil company
- Design of mechanical systems
- Preparation of design specifications

- Preparation, checking or approval of manuals and procedures
- Preparation, checking or approval of design calculations
- Manufacture, testing and commissioning support
- ROV and construction project support

DESIRED SKILLS OR EXPERIENCE:

Technical Experience:

Experience in a subsea engineering environment

Self Managerial Experience:

Ability to work to deadlines and budgets

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- BSc in mechanical engineering or experience in subsea engineering
- Continuing Professional Development
- Ability to articulate learning experiences

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MINIMUM REQUIREMENTS

Education:

BS Petroleum Engineering or equivalent technical field. MS or PhD is desirable, but not required; intensive industry training including appropriate specialized courses and seminars is expected.

Experience:

15 years experience in the drilling industry out of which 10 years are in drilling engineering. Extensive knowledge and experience in the design of horizontal and multilateral oil or gas wells. Knowledge and experience in the application of new drilling technologies and under-balanced drilling are desirable. Must be clearly recognized by both his supervisors and colleagues as thoroughly qualified and highly competent in areas of expertise. Must have demonstrated ability to communicate ideas clearly to work effectively with others, and to utilize this technical knowledge to achieve practical results. Supervisors and Oil company must have confidence in judgment and recommendations.

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Improving pipeline

The PRODUT program helps Petrobras improve operational reliability

Ney Passos, Petrobras Brasil S.A., Rio de Janeiro, Brazil

Most of Brazil's 15,000-km oil and gas pipeline network is more than 20 years old. Consequently, this generates all manner of complex maintenance and renewal issues.

Adding to the complexity is the fact that the network is growing in size. By 2007, the network is forecast to reach over 25,000 km. But as the network grows and modernizes, the system's operational reliability standards must be maintained.

For these reasons, in 1998, Petrobras established a pipeline technological program, called PRODUT. The program helps the company meet these complex demands and deliver technology firsts.

Coordinated by Petrobras' Research and Development Centre (CENPES), the program operates in an interdisciplinary way which brings together Transpetro (Distribution) and Petrobras Production. The program has already helped reduce the risk of leakage and subsequent harm to the environment. It has also reduced operational costs and repair times.

The strategic objectives of the program are to:

- Improve operational reliability of pipelines;
- Increase the lifespan of the existing pipeline network and future construction;
- Increase the operational capacity of existing pipelines;
- Minimize the risk of leaks; permit better utilization through novel repair techniques;
- Reduce the impact of leaks on the environment.

PRODUT is divided into many areas, which enables a broad array of technologies to be developed and delivered. Under the PRODUT umbrella, all of these projects follow the same philosophy as other technological

programs coordinated by CENPES. This ensures that an interdisciplinary approach is maintained, and that different technology managers within CENPES and Petrobras provide technical input and feedback. The goal of the program is to make available and develop technology for the pipeline system, in order to increase reliability and useful life, as well as reducing costs and the risks involved.

The performance of PRODUT is determined by the following guidelines:

- Select projects whose products have a wide application, and a better technical-economic return;



ne performance

reliability, increase capacity, and maintain environmental safety.

- Form teams of technicians from CENPES and other areas of the company that promote greater cooperation in the technological area;
- Include the participation of external institutions, such as universities, engineering companies, manufacturers, service companies and operators, seeking to increase the availability of human and financial resources.

In order to properly define the nature and types of projects that will be researched, Petrobras has formed the CTO-Operational Technological Committee. This committee meets annually, and counts on the participation of the wider technical community, the management of CENPES, and other Petrobras areas such as exploration and production, downstream, transportation, engineering, and bunkering. Such a degree of collaboration within Petrobras' strategic, technical, economic, safety and environmental factors permits continual improvements as well as the definition and prioritization of projects that meet operational and business needs.

Petrobras has invested around (U.S.) \$2 million in PRODUT annually for carrying out R&D projects. About 30% of the projects are also financed by FINEP (Financiadora de Estudos e Projetos - Studies and Projects Financing Agency), through the CTPETRO (Fundo Setorial do Petróleo e Gás Natural - National Plan for Science and Technology for the Oil and Natural Gas Sector) program. Since the introduction of PRODUT, 50 research and development projects have been completed, and 39 other projects are in progress. Some of these are listed below.

Corrosion management

This project seeks to develop and supply prevention, monitoring and automation technology to control internal and external pipeline corrosion. This will provide

concrete benefits by preventing corrosion related failures, increasing operational reliability standards, reducing environmental damage and expanding the lifespan of the pipeline network. In reference to corrosion management projects, there is the evaluation of the corrosive properties of the transported products and oil and the development of methodologies for evaluation of corrosion inhibitors. This leads to a better understanding and control of the corrosive process. Methodologies for monitoring and control of internal corrosion of natural gas pipelines were also defined and optimized.

Leak detection systems

By making these types of systems available, Petrobras' procedures for leak detection are becoming more efficient by helping to quantify and pinpoint oil, gas or other derivative leaks in pipelines. Overall, this improves profitability by reducing the loss of hydrocarbon products and any subsequent impact thereof on the environment. Leak detection technology, to be used in short oil and products pipelines, was defined, with the objective of minimizing product losses with a consequent reduction in environmental impact and in direct, indirect and intangible costs.

A flow and leak detection simulation system, for multipurpose pipelines, was developed in-house, which is currently in the test phase. It is important to add that the effort that Petrobras has been making towards increasing the reliability of its pipelines, with the implementation of the Pipeline Integrity Guarantee Plan, has produced excellent results.

Pipeline rehabilitation

Here the focus has been to establish integrity evaluation criteria that span the lifespan of the pipeline network. Within this project, hydrostatic test methodologies,

A database was developed for the relevant physical and operational characteristics, from a managerial point of view, of all of the company's pipelines. This filled an existing gap, allowing the data to be available to users, at high speed and reliably.



certification criteria and commonly available repair techniques are all being re-evaluated. Petrobras is benefiting through higher pipeline utilization factors, more flexible and economic repair techniques, reduced maintenance costs and enhanced safety.

In connection with the repair of in-service pipelines we can mention welding of in-service pipelines, and the use of composite materials. In the case of the latter, a national company was qualified to carry out this type of procedure, which has already executed various work on Petrobras pipelines. This technology seeks to allow the permanent rehabilitation of pipelines with external corrosion and temporary rehabilitation of pipelines with internal corrosion. It is valid to emphasize that the execution of repairs of in-service pipelines is a technique of great interest, since it avoids shutting down operations, with a substantial increase in the utilization factor of pipelines, and is essential in the case of gas pipelines.

Pigging technology

Although many types of pigs are available commercially, they are not necessarily adapted to the needs of Petrobras. This project has listed the operational needs of Petrobras' pipeline system, and is developing and testing various pig technologies to assess their suitability. Clearly, this will enable Petrobras to improve internal pipeline inspections, reduce the risks of leakage, and damage to workers or the environment.

Additionally, the operating life of the network should be extended as maintenance issues such as corrosion or wear and tear are better managed. Geometric and magnetic instrumented pig technologies were developed as tools

for the internal inspection of pipelines, with the objective of assuring their integrity; as well as reduce risks, avoid emergency interruptions, and reduce operational costs.

The most important result has been the acquisition and consolidation of technology by Petrobras, which makes available services with instrumented pigs, with the ISO 9002 certification guarantee. A national company was licensed to operate with magnetic pigs for defect analysis and geometric pigs - the first in Latin America. It has already inspected more than 10,000 km of pipelines in Brazil and abroad. The main advantages, compared to the hiring of international companies, concerns the economic aspects, in addition to the significant reduction in response time and shorter pipeline shutdown.

Pipeline operation and automation

This project is developing advanced operational, automation and scheduling techniques for pipelines. Benefits include an increase in efficiency and operational safety; reduction in the number of interfaces in multipurpose pipelines; improvement in the quality of products transported; and a reduction in the cost of demurrage for shipping, excess stock and reprocessing losses.

Risk management and reliability

The focus of this project is to develop better pipeline risk and reliability analyses, which will help reduce costs by optimizing periodic inspections and maintenance. Additionally, as risks are reduced, there will be a reduction

A database was developed for the relevant physical and operational characteristics, from a managerial point of view, of all of the company's pipelines. This filled an existing gap, allowing the data to be available to users, at high speed and reliably.

of tangible and intangible costs. Parametric studies were carried out to evaluate the sensitivity of heated pipelines with initial zig-zag geometry to variations in the hypotheses adopted in their project.

These studies, allied to the scale model tests carried out, allowed the commencement of the new PE-3 fuel oil pipeline project, from REDUC to the Ilha d'Água Terminal. This effort included technology of a safety and reliability standard that is substantially superior to previous projects, minimizing the risk of accidents. An improvement to the inspection plan for flexible lines and umbilicals was prepared, using risk-based inspection techniques.

A database was developed for the relevant physical and operational characteristics, from a managerial point of view, of all of the company's pipelines. This filled an existing gap, allowing the data to be available to users, at high speed and reliably.

Another important fact was the creation by the Petrobras Board of Directors of the Special Work Group for the Petrobras Pipelines Integrity Emergency Program, with representatives from nine areas of the company. Its objective is to prepare a work plan, defining and executing actions to study and evaluate the integrity of Petrobras pipelines. One of the highlighted points from the results obtained was the preparation of the Pipeline Integrity Management Standard, which consolidated all the available technology in the company and abroad, with a decisive contribution from the results obtained from various PRODUT projects. It is also valid to emphasize the great participation of the various segments and business units involved, directly or indirectly, with pipeline activities.

The basic objectives of the standard are the following:

- Establish the criteria for classifying pipelines, based on the possible consequences arising from their failure;
- Prioritize monitoring, control and intervention actions, setting the necessary actions for detecting, monitoring and controlling internal corrosion, external corrosion, stresses caused by ground movements and third-party action;
- Define the evaluation procedures and acceptance criteria for the various types of discontinuity as well as hydrostatic test and contingency repair procedures.

By corporate instruction, this standard is now followed in the practices used on all of the company's pipelines.

Pipeline material technology

Members of this project are working to improve existing pipeline materials and coating technologies, again, adapting them to the needs of Petrobras. Benefits will include cost reduction and an increase in the reliability and life of pipelines through a deeper understanding of materials and coating performance.

In partnership with industry, steel with high mechanical resistance and strength was developed for use in large pipelines, in order to increase operational safety and decrease investments in new enterprises. Models for the simulation of pipeline structural behavior were developed with various types of commonly found defects, allowing the evaluation of their resistance as well as the definition of repair needs, assuring higher operational safety and maintenance cost reduction. In connection with defect

The initiatives and implementation of PRODUT pipeline technologies have proven to be very successful. They have enabled Petrobras to harness new technologies and know how. This has been an essential component in the increased reliability and competitiveness of hydrocarbon transportation systems.

evaluation technology, CENPES is considered to be at a world class state-of-the-art level.

Increasing transfer system efficiency

By adding knowledge of alternative techniques to transport greater volumes of products lower levels of investment and short implementation periods will be required. These solutions will help ensure Petrobras production flow and supply to the oil and products markets is operating at an optimum. Studies and tests for the application of drag reducers additives were carried out for oil and products pipelines, and the conclusion was to make their implementation viable in various company pipelines, especially those with utilization factors close to their transfer capacity. The next challenge is the development of proprietary additives and/or from new suppliers, which will cause a great increase in demand for their use.

Pipeline design and construction

The project seeks to identify and develop new pipeline projects, construction and conditioning techniques. Here, benefits will include a reduction in costs for new enterprise; a reduction in the environmental impact of new enterprises; and maintain the Petrobras reputation at an international level.

For example, an evaluation of the operational safety of the Guanabara Bay pipelines was carried out. This process included the mapping and registration of all buried and submerged pipelines, as well as an overall analysis of the structural problems that were detected. The project carried out a structural analysis of all pipelines between REDUC (Petrobras Duque de Caxias Refinery) and the Ilha d'Água Terminal. New operational procedures were defined and followed, and the necessary physical modifications to the pipeline network were designed.

Among the results obtained, the viability of the safe flow of fuel oil produced at the refinery should be highlighted. Even with pipeline PE-2 out of operation since January 2000, we were able to increase its processing load to lev-

els greater than previously practiced, with highly positive financial results. Within the global pipeline industry, the CENPES team that developed this work has become recognized as world leaders in the analysis of submarine thermo-mechanical heated pipelines.

Future prospects

With these positive results, in 2002 Petrobras decided that PRODUT would continue for a further five years. Among the projects in progress, we point out the Pipeline Technology Center (CTDUT - Centro de Tecnologia de Dutos), which has the objective of creating an institution by which the goods and services industry, related to pipelines, can train and qualify personnel, develop and certify materials, equipment and procedures.

CTDUT, which is in the initial phase of construction, will be a Laboratory-School, with actual size field installations, for research and development of new technology, testing of products, equipment and systems used in pipeline networks and certification of specialized pipeline personnel.

The participants in CTDUT will be Petrobras, PUC-RJ (Pontificia Universidade Católica - the Catholic University of Rio de Janeiro), and companies established in Brazil that have activities related to pipelines, research institutions and other universities with interests in the pipeline sector.

Other indirect results can be mentioned, such as a greater integration of Petrobras with the R&D community, a large number of works presented and the marked presence of Petrobras at international pipeline congresses. Of the many projects in progress, some deserve to be highlighted. These are:

- Establishment of criteria for the selection and performance evaluation of chemical products used to minimize the presence or formation of black powder in gas pipelines;
- Development of a test methodology for identifying the susceptibility to corrosion of pipelines under tension;

- Evaluation of state-of-the-art dedicated sensor technology for the detection of small leaks;
- Development of pressure signature leak detection systems;
- Analysis and selection of gas pipeline leak detection systems;
- Calibration of models to be used in the evaluation of the fatigue life of pipelines with slight indentations, without holes subjected to variable loading;
- Evaluation of the efficiency of two-part metal sleeves for repairing pipelines when subjected to pressures of collapse and cyclic pressures;
- Definition of the system for managing pipeline correlation inspections;
- Definition of procedures and development of equipment for measuring the tensions in pipelines by the ultrasound method;
- Development of technology for instrumented pigs, for corrosion inspection in risers and special lines;
- Development of multi-size pigs for cleaning and inspection in production pipelines with variations in diameter;
- Development of robots for intrusive operations in pipelines;
- Development of a PLEM, with an underwater electric actuator;
- Development of a database of geomechanical data of the pipeline system;
- Analysis of the behavior of pipelines under thermal loading and mass movements;
- Analysis of the ground-pipeline interaction of Serra do Mar pipeline systems;
- Characterization of new technology for thermal isolation of buried pipelines;
- Analysis and definition of the best inspection techniques for the making of riser welds.

The initiatives and implementation of PRODUT pipeline technologies have proven to be very successful. They have enabled Petrobras to harness new technologies and know how. This has been an essential component in the increased reliability and competitiveness of hydrocarbon transportation systems. PRODUT technologies have delivered greater levels of overall efficiency in E&P, refining and distribution of oil, gas and derivatives. 🔥



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CTDUT - A Partner in R&D Projects

Stella Faria Nunes - CTDUT, Project Manager and Raimar Van den Bylaardt, President CTDUT

CTDUT (Pipeline Technology Center) located in Duque de Caxias, Rio de Janeiro state, was inaugurated in 2006. The preliminary concept that would later give shape to CTDUT came from an earlier perception that there was a gap that should be filled for the benefit of the worldwide pipeline industry and society as a whole. That empty space concerned the need for an institution that would be entirely dedicated to stimulate technological development that could function as a space for debate, where current expertise could be disseminated and enhanced, while providing a place that was projected since its early days to become a technological milestone to the pipeline industry.

The Center was born from an initial association between PETROBRAS (Petróleo Brasileiro S.A.), TRANSPETRO (PETROBRAS Transporte S.A.) and PUC-RIO (Pontifícia Universidade Católica, Rio de Janeiro) as a non-profit private institution that was gradually equipped with special facilities commissioned with the unique objective of supporting an ever growing demand for well trained people, services and equipment specially created to facilitate pipelines operational management.

As a consequence of the market recognition of CTDUT's value the association grew further and nowadays there are 35 institutions associated to the Center that, altogether, form a congregation of some of the very best players in the Brazilian pipeline segment. R&D Institutions, universities, and private companies from vastly distinct areas compose a society that is working together focused to improve the current technology available.

As a technology center, CTDUT holds a significant projects' portfolio that ranges from the development of computational systems up to the construction of short range



pipelines exclusively dedicated to testing the most diverse equipment and procedures and training people. All projects are developed in partnership with other interested parties, whether of private or public nature.

With the support of public financing from CTPETRO (Fundo Setorial de Petróleo e Gás Natural) funds, provided through FINEP (Financiadora de Estudos e Projetos), and coupled with additional financial support from PETROBRAS, the Center manages a number of projects of its own and provide means to help external projects majorly lead by teaching institutions working closely with the pipeline industry.

Internal projects currently include the construction of two testing and training pipelines, each dedicated to different hydrocarbon phases - oil and gas - that will be about 2.5 km length, and 12 and 16 inches diameter, respectively. Both pipelines are being designed to fulfil requirements from senior researchers and professionals of the pipeline industry who actively participate in working groups specially created to suggest guidelines based on up-to-date and future needs and trends of the industry.

Among all external projects currently in CTDUT's portfolio, seven deserve special mention. Some of the

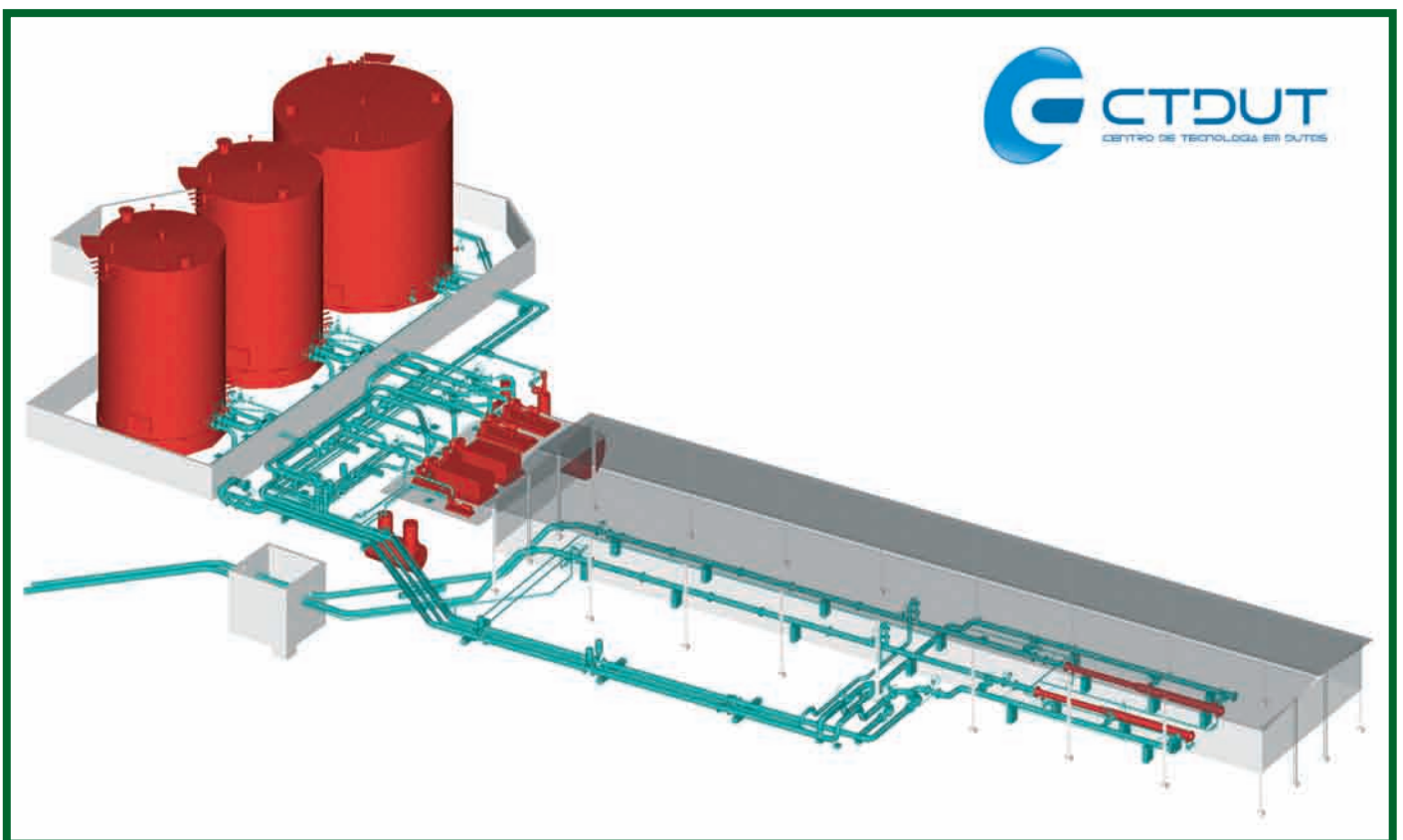


the monitoring of cathodic protection deglutination from underground pipelines through the application of extensometry will be studied. Studies for the definition of sensors' density that will optimize the relation between the system and the reliability achieved with the proposed technique will also be developed with the objective of monitoring parameters like the soil (inclination and pressure), pipeline's deformation due to internal pressure and flexion, and deformations caused by the cathodic deglutination and/or corrosion.

best Brazilian universities and research institutions like PUC-RIO, INT (Instituto Nacional de Tecnologia), UFRJ (Universidade Federal do Rio de Janeiro), UERJ (Universidade do Estado do Rio de Janeiro), UFF (Universidade Federal Fluminense), and IME (Instituto Militar de Engenharia) are in charge of developing research and achieving results of utmost relevance to the worldwide pipeline industry.

ERBF is the nickname given to the project coordinated by Professor Arthur Braga, from PUC-RIO in partnership with INT, which is focused on the development of tools and field work methodology necessary to the installation of extensometers based on the BRAGG net in optical fibre placed on the pipelines' surface during its construction. At the same time, possible solutions for

Professor Luís Fernando Alzuguir is the technical coordinator in charge of ARRASTE. The project will develop fundamental studies about the phenomena involved in processes that provide fluid flow attrition reduction. Such fundamental studies will constitute the basis for subsequent research at lab and pilot scales that will focus product flow in petroleum dedicated pipelines and heavy oils transport. All fundamental studies will be performed at PUC-RIO's Fluid Engineering Lab, while pilot studies will take place at CTDUT's oil testing pipeline. The research will investigate the effects of attrition reduction caused by the addition of attrition reductant polymer, by



the application of internal revetment, and surface modification at submillimetric and nanomillimetric scales, producing lubrication effects over the main fluid, with great potential of employment to heavy oils transport.

TRANSVAL, also under Professor Alzuguir's responsibility, proposes the creation of an infrastructure to perform tests and studies about valves employed in pipeline transportation. More specifically, the proposition is to build lab and field scale facilities that will allow the study of hydraulic transients when relief, blocking, and control valves are opened and closed. The lab scale facilities will be placed at PUC's Fluids Engineering Laboratory, while the real scale facilities will be constructed at CTDUT's site. Both facilities will be able to answer an existing demand for valves' testing and certification for the application in flow computational simulation for pipeline transportation, and petroleum derivatives' terminal load and unload.

Professor Jose Luiz de Medeiros is working on SDVDU-TOS2 at UFRJ's Chemistry School, together with UERJ. This Project aims at developing a Leak Detection System (LDS) supported by Real Time Monitoring and Real Time Modeling of pipeline networks under surveillance provided by SCADA technologies. The Project proposes and implements computational tools for detection, location and quantification of abnormal occurrences like sudden cracks, leaks, line obstructions, unexpected valve actions and machine failure. The basic approach relies on developing pipeline dynamic simulation tools, in the

context of auto-regressive stochastic predictors, which are constructed with time series of records of pipeline variables like pressures and flow rates. The stochastic predictors are created by forcing, periodically, statistical adherence to pipeline SCADA records. Once created, these tools can be used as pipeline simulation resources, so that anomalies can be detected, identified, located and quantified by processing, statistically significant, observed discrepancies between measured field variables and the corresponding predicted (anticipated) values. The necessary pipeline operation data and abnormality (leak) data, which will be used for developing the stochastic predictors and the entire LDS, will be gathered via pipeline flow experiments with artificial leak occurrences that will be conducted at CTDUT pipeline facilities and at a small-scale water flow loop installed in Chemistry School.

Also inside UFRJ's facilities, Professor Segen Estefen is coordinating INSTALINER, a major project that has the objective of placing a 120 meters length real scale polymeric liner in CTDUT's 12 inch steel oil testing pipeline. The project's main goals are to develop a methodology for selecting the polymeric material to be employed in the liner, including thermo-mechanical, tenacity and fracture testing; numerical simulations of storage, installation and operating conditions, taking into consideration the liner's defects due to installation and pipeline ovalization; establish the liner's installation parameters at the working field; and putting the liner in the pipeline by applying collapsing and reduced internal diameter techniques. These stages will be followed by the assessment of each installation technique and respective operational



behaviours, and the recommendation for materials' selection, analysis methods and installation procedures.

The research project supervised by Professor Paulo C. Pelanda, from the Military Institute of Engineering (IME), SISGED, strives to develop a Pipeline Georeferencing System based on inertial pipeline inspection databases. The system will be able to estimate the 3D trajectory of a pipeline using an inertial navigation system and a set of GPS surveyed control points. The first step of the project includes the development of a computational tool used to simulate the dynamical behaviour and to compute position of a typical pig along its trajectory within the pipeline, and the installation of a test pipeline in CTDUT's area. The test pipeline loop will be about 2,5 Km long and will have a 12" nominal diameter. These tools, along with full scale facilities, will be used for evaluating a prototype system to be developed in a second phase of the SISGED project. At the end of the development, the resulting system will be useful for helping other in-line inspection tools to identify the position of features or defects along the pipeline as well as to precisely estimate critical radii of curvature.

ADDUT project, coordinated by Professor Ana Cristina Bicharra from UFF, aims to develop studies about new techniques that will detect and find out the cause, whether internal or external, of small leaks in pipelines. The research is based on the application of artificial intelligence techniques, more specifically, Neural Nets and Markov nets. The study will, subsequently, be directed to develop a computational prototype to provide data and support diagnosis of small leaks in pipelines containing monophasic liquids.

There is a worldwide consensus about the pipeline's growing strategic importance as a means of transport for energy resources. Therefore, market specialists predict that the following five years will see an amazing demand for new technologies, manpower and materials in pipelines. The demand will require more capacity and more reliability in terms of quantity and quality. CTDUT itself and the projects in its portfolio will help to facilitate tools for the industry to achieve such developments and become able to respond to this demand promptly, while getting prepared to answer future challenges. ●

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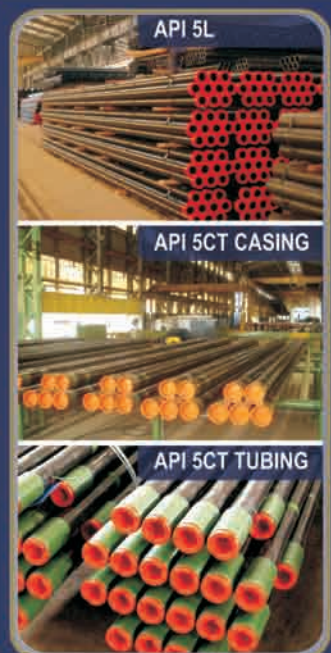
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5 9/16 (5.563), 6 5/8 (6.625), 8 5/8 (8.625)

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Tecnologia e inovação com respeito ao meio ambiente.

AQUISIÇÃO SÍSMICA 2D, 3D E 4D; DIAGNÓSTICO AMBIENTAL E MONITORAMENTO DE AQUÍFEROS; REMEDIAÇÃO; CADASTRAMENTO E INSPEÇÃO DE DUTOS.

As operações nos mais diversos ambientes geográficos e geológicos, honrando prazos e mantendo elevados padrões de segurança e saúde ocupacional, constituem o compromisso renovado da Georadar. Nós operamos com extrema atenção ao meio ambiente e responsabilidade social em todas as atividades, no Brasil e no exterior.

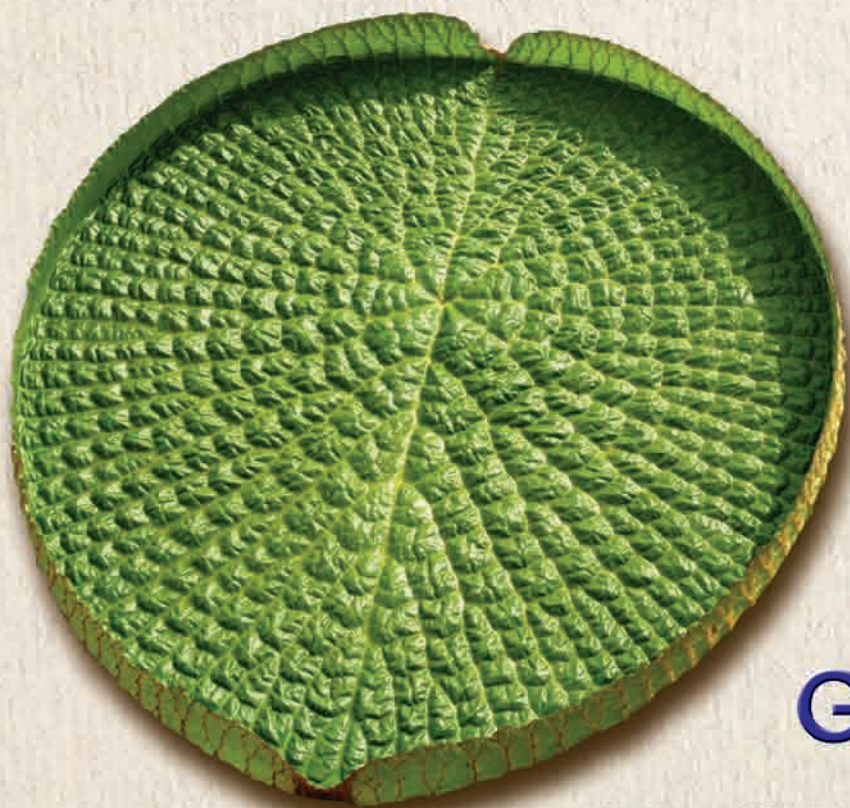
TECHNOLOGY AND INNOVATION WITH RESPECT TO THE ENVIRONMENT

2D, 3D AND 4D SEISMIC ACQUISITION; ENVIRONMENTAL INVESTIGATION AND GROUNDWATER MONITORING; REMEDIATION; INTERFERENCE NET RECORDING AND PIPE LOCATION.

The operations in the most diverse geographical and geological environments – complying planned schedules and high standards of occupational safety and health – constitute the compromise renewed by Georadar. We operate with extreme attention to the environment and social responsibility in all of our activities, in Brazil and other countries.



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GEO RADAR

A Siemens tem orgulho de contribuir para a auto-suficiência de petróleo no Brasil, promovendo o crescimento de nossa indústria nacional.



Maximização da produtividade e fornecimento de aplicações em upstream, midstream e downstream. Tudo o que uma empresa necessita para ser competitiva no mercado de óleo e gás!

A Siemens fornece desde componentes individuais, produtos e sistemas até soluções totalmente integradas em automação e controle, equipamentos rotativos, energia, segurança e proteção contra incêndio, telecomunicações, TI industrial e serviços para todo o ciclo de vida das plantas. Desta forma, garantimos que todas as áreas das plantas sejam otimizadas e todas as suas necessidades atendidas. A conquista da auto-suficiência é mais um exemplo de que a Siemens está presente no mercado brasileiro, contribuindo para o seu crescimento com eficiência, qualidade e respeito ao meio ambiente.

<http://www.industry.siemens.com/oil-gas/pt/>

Soluções para a Indústria de Óleo & Gás.

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