We want to hear from you: If you have comments about any of the articles in this issue or any ideas for future issues, send them to currents@sbmoffshore.com.

Currents is issued by the Group Communications Department.
Welcome to Currents.

Participating at CERA Week this year it was refreshing to hear the recurring point that oil and gas companies and service providers need to collaborate more. It is something that we advocate in order to reverse the downward trend of reduced ROI experienced by the majors – a situation which is not sustainable if we are all to survive and thrive in the long-term.

We also believe that the new ways of working is in integration with clients through a long-term collaborative process that values the competitive edge that the likes of SBM can bring in response to the dialogue. The traditional way of comparing service providers on the face value of price alone is no longer an appropriate method in this new era.

Please read on to understand the competitive edge that SBM can offer – the expertise of our offshore operations, our pioneering technological advances and the local content and world-class product that we can deliver with our state-of-the-art, joint venture shipyards in the growth markets of Brazil and Angola.

This issue coincides with the OTC conference in Houston and we are honored to accept one of the Spotlight on New Technology awards for an industry first – our Very High Pressure Fluid Swivel. The VHP swivel will help to unlock the Gulf of Mexico’s lower tertiary reservoirs and complements our specialised product portfolio for deeper and more complex reservoirs as well as harsher environments. I would like to thank the jury for this prestigious accolade and our engineering team for their ground-breaking work, which year after year proves SBM’s technology leadership position in the industry.

SBM will continue to seek safer and more cost effective solutions to the challenges faced today and tomorrow. We look forward to working together with our clients to make the future happen.
10th anniversary for SBM’s FPSO engineering standards

In 2004 a suite of proprietary Engineering Standards for leased FPSOs was implemented by SBM – the start of a pioneering journey. This year SBM celebrates the 10th anniversary of these Corporate Engineering Standards (CES), which have been the engineering foundation for 18 SBM FPSO projects and relocations. The CES was the industry’s first set of FPSO specific design standards wholly applicable to converted FPSOs. Today SBM still leads the industry in this area.

ABS has played an important part in the development of the CES - SBM’s objective from the start was to have all standards pre-approved to ABS Class Rules.

The CES remains the bedrock of our leased FPSO projects and it continues to evolve as new specifications are added. We are going well beyond the initial remit of ‘Engineering’ specifications - several construction and commissioning specifications exist and this area will be expanded. Therefore, ‘Corporate Engineering’ no longer adequately describes our Standards.

SBM is happy to inform our clients and stakeholders that we are rebranding our CES as the ‘Group Technical Standards’ (GTS).

Existing CES specifications will be re-issued in GTS format. We will present them to the four SBM execution centres around the world and provide further coaching on how the GTS are to be correctly applied on projects.

Thank you to all who have contributed to making the CES a success over the last 10 years - especially to our clients who have contracted our FPSOs against functional specifications, accepting the CES as the high standard for their projects.

SBM’s Green solution for associated gas

With gas the next challenge on the industry’s horizon, SBM Offshore is playing its part to pioneer solutions. The company participated in the Gastech Conference in March held in South Korea using the opportunity to present the latest developments on our FPSO with Gas-To-Liquids (GTL) concept to the major players.

Developed together with our technology partner, CompactGTL, the concept is based on their innovative process for chemical conversion of associated gas into synthetic crude oil. With flaring regulations in many countries becoming more stringent and, with oil exploration and production increasingly located in remote and deep waters, the problem of associated gas disposal has become an expensive and tricky dilemma for the industry. SBM/CGTL’s solution to avoid flaring is based on an adaptation of conventional GTL technology for smaller scale applications enabling the GTL plant to fit on an SBM FPSO vessel. The result is a floating production system allowing for a capacity up to 100 MMscfd of gas, 100,000 bbl/d crude production and 7,200 bbl/d GTL liquids production. The end product for the client is valuable synthetic oil, which can easily be mingled with the conventional crude oil increasing its value while requiring no separate storage or offloading logistics. The concept can be applied to an Extended Well Test FPSO or on a Full Field Development FPSO.

Rebranding

SBM Corporate Engineering Standards

GTS Group Technical Standards

Speaker: Francesco Criminisi - FLNG Development Engineer
**Mid-scale FLNG tests promising**

Engineers at SBM are busy developing our pioneering mid-scale Floating Liquefied Natural Gas (FLNG) concept for stranded gas fields. With patents in place, engineering is continuing and model testing has taken place to verify computer simulations.

The team conducted extensive model tests of the twin-hull FLNG concept in the Marin facilities in The Netherlands. The results were very encouraging as they demonstrated excellent seakeeping behaviour and less roll motions than would be expected for a ‘normal’ hull. Furthermore, side-by-side offloading between the twin-hull and a regular LNG carrier was tested and this also showed very stable behavior.

The entire testing programme was performed in two different model tank basins, took almost five weeks and comprised more than 56 different tests. It has further raised the confidence level in the twin-hull concept and will be a good stepping stone to a full FEED.

SBM’s core position is for midscale FLNG (1.5-2 mtpa) conversion. Many of the FPSO conversion technologies and capabilities that SBM has in-house are equally applicable to the FLNG conversion concept, especially around tanker refurbishment and life extension, turret mooring systems, gas processing, safety, operability and maintainability.

**FPSO financing**

In addition to the company breaking boundaries with state-of-the-art technology, SBM Offshore has been taking pioneering steps in the financing of FPSOs.

A 1.0 billion US dollar framework agreement between the Export-Import Bank of China (CEXIM), Dutch Bank ING and SBM Offshore was signed in March 2014. The presence of the President of China, Xi Jinping, underlined the importance of this agreement, which should lead the way for the financing of FPSOs Cidade de Maricà and Cidade de Saquarema by the Beijing-headquartered bank. Traditionally involved in the support of the shipping industry in China but now keen to branch out, CEXIM is showing its willingness to extend financial solutions to the offshore services industry.

The cooperation between the three parties opens the door to more opportunities on the FPSO construction front in China, with CEXIM open to committing up to one billion dollars over the next three years. The framework was a direct follow-on from SBM Offshore’s decision to engage the Chinese yard in Guangzhou to convert and refurbish three of its FPSOs.

In February, SBM Offshore accepted an award from Project Finance International (PFI) for the ‘2013 African Oil & Gas Deal of the Year’ for its FPSO N’Goma destined for offshore Angola later this year. The prestigious accolade recognised the success of the financing deal - the biggest ever seen for an Angolan FPSO, which was achieved promptly and efficiently, despite the complex nature in terms of location, multiple stakeholders and timeframe. With less than three months between Request for Proposal (RFP) and financial close in July 2013, the US$600m of debt on an 8.5 year tenor supported an Angolan oil field, Angolan shipyard and an Angolan operator. The project company behind N’Goma is Sonasing - a consortium comprising SBM Holding (50%), Sonangol (30%) and Angola Offshore Services (20%). The project will benefit from stable revenues from the 12-year charter arrangement with Eni Angola, with payment obligations backed by its parent Eni. The syndicate of Banks include BNP Paribas, ABN-Amro, BTMU, ING, Rabobank, SMBC, SG, Mizuho, Natixis and CIC.
SBM Operations
on 24/7 safe performance offshore
The Managing Director of SBM Operations worldwide may be office based but he is not afraid to get his hands dirty offshore. Peter Senkbeil’s vision and his strategy to implement it require being in the midst of the action on SBM’s vessels and staying in close communication with clients.

“My vision, my role in the company is to provide customer orientated solutions and to ensure safe and reliable operations,” says Peter Senkbeil who joined SBM just over a year ago with a wealth of international operations experience under his belt. He has the advantage of approaching operations from the client’s perspective. Prior to joining SBM he was Chief Refining Officer at Petroplus and held several high level roles with Exxon; he also sat on the ExCom of Esso Germany.

Peter and his team are committed to regular client visits, which help SBM meet the more day-to-day needs as well as anticipate their future requirements. In addition, open discussions with the client on board representatives (OBR) ensure daily communication about operations offshore. Regular visits by his managers to where his team operates – on board the FPSOs operating around the world and the shore bases, which support the vessels – mean that Peter has a direct link to the action. As soon as he took on his role he made a point of visiting some of the FPSOs to familiarise himself with SBM’s key business and to establish the vital contact that he values.

“To be able to respond quickly to our customers’ needs is of utmost importance; this is why we regularly interact. The importance and value of listening to our clients cannot be under-estimated,” says Peter Senkbeil, whose international career has spanned 34 years.

**Operations begin**

The journey on a long-term lease and operate contract for an FPSO begins with a transition from the project execution team to the operations team. There is a long Operations Readiness process to complete before this handover occurs, and both divisions of the company are now working more closely than ever to ensure that once operations take the reins the production levels that the Company has committed to are safely achieved.

“Any delay in start-up offshore has a huge impact for us and our client,” adds Peter Senkbeil. “Not just in terms of potential financial loss for SBM and our partners due to lost revenue and fines for loss of production but also the negative impact it would have on our clients’ confidence in our ability to do what we promise to deliver.”

**Asset integrity**

A key focus is on further developing maintenance strategies to ensure safe and reliable operations over the lifecycle of the vessel. Contracts have gone from an average of less than 10 years to 20 years for the most recent contracts for the Petrobras pre-salt FPSOs.

Paul Whittle, Onshore Technical Manager for SBM’s Brazilian six-strong fleet comments on what matters to our clients “A unit of happiness is a barrel of oil safely produced.”
“This change in our business - longer life spans for vessels - means that we need to evolve our maintenance approach to accommodate the different needs that the vessels will invariably require during this extended time period. It is vital to keep continuity in our standards and to pay attention to detail. All SBM assets must be efficiently maintained in a condition to safely deliver industry leading performance to clients over the full contract life. That is our goal,” explains Peter who is a graduate in Mechanical Engineering from Hannover University.

The emphasis is on a proactive approach. It requires periodical planned shutdowns to test and review the condition of equipment and planning to take any actions needed to remedy a potential problem before it becomes a necessity.

For example, regular tests of pipe wall thickness allow SBM to predict potential problems by observing trends in corrosion. “By planning we avoid surprises,” he adds.

“We’re under-going a huge transformation from a more marine-based business to a processing business. Our FPSOs are offshore production plants, which require a different skill set and a different approach from shipping,” explains Peter Senkbeil, Managing Director of SBM Operations.

SBM’s first pre-salt FPSO operating safely
Paraty is the first in the mega pre-salt FPSOs for Petrobras - in operation since June 2013. Thierry Duretz, Operations Manager FPSO Cidade de Paraty has first-hand experience.

He is based at the Santos onshore base whose role is to provide efficient support to the offshore team.

“The FPSO’s complexity and large topsides are new to us. The ultra-deep water and the need to re-inject the gas at much higher pressure, over 500 bar, is a new benchmark. This has meant a big learning curve and required additional training for the offshore teams. Paraty is a huge achievement for SBM engineering and in terms of operations we are happy with the consistent uptime. We are still learning and we feed back this performance information to SBM’s Technology team,” says Thierry Duretz.

Peter Senkbeil adds “This continuous feedback loop from operations to the engineering division of SBM ensures that we continually improve our technologies, which down the line optimises our operations.”

By tapping into this experience in operations, SBM engineers can understand first-hand how the new mega, pre-salt, FPSOs, which SBM call ‘Generation 3’, operate and identify areas to improve.

Simon Catchpole, former Production superintendent FPSO Cidade de Paraty (now on FPSO Brasil): “The fundamental change is that previously FPSOs had oil and some gas processing systems which were very simple, whereas now the unit not only dehydrates the gas but also separates the CO2 and re-injects it back into the reservoir. This is more favourable for environmental reasons and also for the customer specification.”
This invaluable information is particularly important for future designs – Cidade de Ilhabela is benefitting from this input from Paraty.

The feedback will also further improve safety in operations.

“Although the pressures that the Generation 3 (G3) FPSOs deal with are much greater, the same standard for safety procedures offshore is followed. Compressors with low or high pressures both represent risks and attention to HSSE remains the top priority for SBM,” says Thierry Duretz.

However, with the new G3 FPSOs it does mean that Process Safety Management (PSM) becomes a much bigger driver.

“PSM is of paramount importance. Some of the new processing units that we have on our FPSOs were previously only found onshore and the implications for safety by now being offshore must be an integral part of PSM,” underlines Peter Senkbeil.

Help from local partners

A positive development in operations is due to SBM’s partners in the FPSOs wanting to play a more active role. “Our partners are becoming more involved and this can be an advantage where they play the role of local partner in the markets where we operate. Their local knowledge complements what SBM brings. For example Sonangol, our partner in OPS, the entity which operates FPSOs offshore Angola, helps us with the human resource issues and the nationalisation of our operations in the country as well as helping us to be more conscious of the needs of local authorities,” says Jean-Bernard Poilpre, Operations Director for SBM Operations.

“Ian Mackay, OIM on FPSO Cidade de Paraty: “Paraty is our 1st G3 vessel and although more or less the same size vessel as previous FPSOs, the topsides are much different. We have much higher gas compression pressures of over 500 bar compared to previous vessels and there are more compressors on the gas train. In addition we have the CO_{2} removal system using membranes – this technology is new to us.”

One difference for the pre-salt FPSOs compared to previous generation FPSOs is that the crude oil capacity has increased; the oil is lighter and of better quality making it easier to process offshore. However, the associated gas contains high levels of CO_{2}, which must be separated and re-injected at very high pressure, making the topsides significantly more complex than earlier Generation 2 vessels.

“Our objective worldwide is to continue to increase the number of nationals employed in the countries where we operate,” he adds.
Although oil exploration in the US GoM Lower Tertiary started many years ago, only two fields are in production today due to the extreme challenges in the area. Up until recently no technology existed to overcome the inherent difficulties that come with these ultra-deep and ultra High pressure/High temperature (HP/HT) fields.

Furthermore, Federal Law heavily regulates well testing in the Gulf of Mexico and prohibits the short-term well testing practices performed in other parts of the world. Consequently well productivity data is in short supply for operators, leading to increased uncertainty, and a move towards phased developments to mitigate risk, as seen on two of the Lower Tertiary projects.

SBM is pioneering new cutting-edge technology that will offer an economic and technically viable solution and so enabling FPSOs to be more widely used for the extremely challenging Lower Tertiary fields. The added advantage is that these solutions are ideal for both Early Production and Full Field developments. These bespoke engineered FPSOs should help to propel the industry into a new era of production in this region of the Gulf of Mexico, enabling the clients to exploit the billions of barrels of recoverable reserves that it is estimated to contain.

The FPSO Turritella for Shell’s Stones’ development is SBM’s ground-breaking move into the region. Due to start operations in 2016 it will represent an exciting new chapter for FPSOs, on several accounts. As well as being the deepest production unit in the world, it will comprise another SBM industry-first; a disconnectable turret with steel risers.
SBM is also forging ahead to fill the remaining technology gaps in the industry and has developed two new technologies. The MoorSpar® and the Very High Pressure (VHP) Fluid Swivel will enable the Gulf of Mexico concept to become a cost effective reality by enabling larger disconnectable FPSOs for full field developments in this particular region.

**Technical Challenges**

Some Lower Tertiary reservoirs appear to be poor quality, leading to low recovery factors. The expected recovery factors for some reservoirs is thought to be around 10% using conventional techniques, whereas ‘best in class’ oil recovery factors for offshore fields worldwide is now around 60%. However, un-deterred the operators have launched a series of industry-wide initiatives to sponsor the oilfield service industry to fill the key technology gaps for subsea and well equipment. Due to the characteristics of the Lower Tertiary reservoirs the key challenges include:

- some of the deepest reservoirs ever developed in the world (many between 8,000 and 10,000m below sea level)
- a thick salt layer making seismic imaging difficult, drilling and well workovers costly
- Ultra HP/HT conditions - up to 1,400 bar (20,000 psi) or more
- Injection of water and/or gas for enhanced oil recovery (EOR) will require surface pressures of up to 1000 bar
- Riser systems required to connect subsea wells to a floating facility are beyond the capabilities of conventional flexible risers
- Prevalent hurricanes
- Exposure to prolonged high currents, known as the “Loop Current”

The FPSOs for Shell and Petrobras are both relatively simple processing units, with no reservoir pressure maintenance in terms of water or gas injection. The Early Production Systems (EPS) allow the operator to gain an understanding of the reservoir performance from a small number of wells, before deciding on the best full field development strategy. The use of an FPSO minimizes the need to run a long export oil pipeline across difficult seabed terrain in ultra-deepwater.

To avoid exposure to hurricanes, FPSOs operating in the GoM need to be disconnectable, which is typically achieved by releasing a buoy to which the risers and mooring lines are attached – the buoy then sinks to a pre-determined depth. Once the storm passes, the FPSO returns and the buoy is reconnected and production recommences.

However, this type of development has limitations due to the maximum suspended weight that the disconnectable buoy can support; depending on water depth and riser design, a maximum of six to 10 risers and umbilicals can be accommodated. SBM, in close collaboration with Shell, has developed for Stones the world’s largest disconnectable turret, complete with several new components needed to enable the massive buoy to be safely connected and disconnected.

Coupled analyses of steel risers and FPSOs enable SBM to optimise both the riser design and the vessel motions and excursions.

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**Technical Solutions for the Lower Tertiary Paleogene Fields**

To meet these challenges, SBM has steadily been developing and qualifying a range of new technologies. In addition, SBM is finding new uses for existing technologies to increase productivity, efficiency and safety. Three examples of the most prominent developments:

1. **Disconnectable FPSO with Steel Risers for Early Production**

   SBM Offshore is currently building the FPSO Turritella (for the Stones development), which will be the deepest production unit ever installed, the deepest FPSO and the first disconnectable system with steel risers. Currently, only Petrobras has an FPSO operating in the Lower Tertiary area on the Cascade Chinook fields – which is the first FPSO approved for use in the U.S. sector of the Gulf of Mexico.
2. Disconnectable FPSO with Steel Risers for Full Field Development

Typically, full field developments require a larger number of risers and umbilicals, which a disconnectable turret cannot accommodate. Hence, SBM has developed the MoorSpar™ system, which is supported by a conventional, slender spar type structure, with the capacity to support more risers and umbilicals. The MoorSpar™ concept is the result of over seven years research and following extensive model tests, it is ready to enter a major project FEED.

The concept makes use of a yoke on the FPSO, which is elevated on disconnection from the MoorSpar™. This simplifies the riser design, as the spar remains floating when disconnected and the MoorSpar™ size can be adjusted to the riser loads. Moreover, when connected the yoke decouples the FPSO motion from the risers, enabling the use of simple steel catenary risers instead of the more expensive lazy wave configurations.

To allow water and/or gas reinjection into Lower Tertiary fields, pressures are needed well above the current industry swivel limits of 520 bar. The solution is SBM’s Very High Pressure (VHP) Fluid Swivel, which has been selected as a winner of the 2014 OTC Spotlight on New Technology award. SBM has designed and built an 830 bar swivel design, which successfully passed a full qualification programme, including long duration endurance runs. This new design has the capability to reach pressures of 1,000 bar, which should be sufficient for all applications foreseen today.

3. Deep Draft Semi-Submersible

For smaller fields where the client selects pipeline export as the preferred option for field development, SBM’s DeepDraft semi-sub is a cost effective solution and a proven design. Still holding the record for the world’s deepest production semi-sub, the Independence Hub semi-sub is installed in the GoM in 2,415m water depth since 2007.
New SBM technologies

The FPSO coupled with the MoorSpar™ technology represents a cost effective solution by being able to support a large number of steel risers for a full field development, where disconnection is required.

MoorSpar™

This new SBM technology permits an FPSO to take a higher riser load, and yet still allow disconnection to sail away from hurricanes. The MoorSpar™ system can be very advantageous for ultra HP/HT reservoirs as it is specifically designed to support steel risers.

The system combines several proven technologies to provide a unique new solution for offshore field developments. It consists of a truss-like structure set above a long, slender buoy, which is moored to the seafloor and coupled to steel risers.

An FPSO is connected to the facility through a standard articulated yoke system which includes a gimbal table to accommodate the roll and pitch motion of the vessel. The yoke connects to a cone on the top of the MoorSpar™, which incorporates a roller bearing to allow the FPSO to weathervane.

Steel risers are connected to the MoorSpar™ facility at riser porches located along the keel of the buoy. The riser is then linked to internal piping, which is routed up through the central column and then across hard piping and swivels to the FPSO.

By decoupling the FPSO motion from the risers, by means of the articulated yoke, the MoorSpar™ enables the use of simple steel catenary risers versus more expensive steel lazy wave risers.

VHP Fluid Swivel

To maximise the recovery of oil from reservoirs, operators use a range of techniques for pressure maintenance and oil displacement. This typically requires injection of a range of fluids into the reservoir; enhanced techniques include use of WAG (water alternating gas injection) and water dosed with chemicals such as polymers.

To do this from an FPSO located in areas where the vessel needs to weathervane, as is the case in the GoM, one or more high pressure fluid swivels is needed. The current industry limit is around 520 bar (7500 psi) – a limit inadequate for deeper HP/HT fields. SBM’s development programme, launched in 2009, has resulted in a patented technique to allow the swivel seals to accommodate much higher pressures. The resulting VHP fluid swivel is suitable for water injection, gas injection or WAG service.

During 2012 and 2013 extensive tests were performed on the full scale prototype, culminating in a successful long-term endurance run at 830 barg (12,000 psi). The swivel design can accommodate operating pressures up to 1,000 bar (14,500 psi) and further tests during 2014 will complete qualification at this pressure.
Work is proceeding at full speed to fulfill SBM Offshore’s multi-vessel contract obligations to Petrobras for offshore Brazil. The supply of three complex and large-scale Floating Production Storage and Offloading (FPSO) vessels is a challenge for which SBM has the expertise and track record.

The three units are vital to support the client’s production targets. In February, Petrobras announced a new pre-salt production level of 412,000 bopd in the Santos and Campos basins and the plan is to continue increasing the level. This new daily production record demonstrates the high-productivity of the pre-salt fields. According to Petrobras, pre-salt will account for 52% of its total oil production in 2018, illustrating why FPSOs specifically engineered for the characteristics of these basins are so important.

Ilhabela berthed safely at Niteroi in mid-January 2014, having arrived in Brazilian waters following her 10,625 Nm (19,678 Km) voyage from the Chengxi (CXG) yard in China, where the hull underwent conversion and refurbishment. The team at SBM’s joint venture Brasa construction yard in Rio de Janeiro immediately started work on the lifting and integration of thirteen locally-built modules onto the hull. The program was successfully completed at the end of March.

The next FPSO in line for delivery to Petrobras during the second half of 2014 is Cidade de Ilhabela. Once in operation Ilhabela will be SBM’s largest FPSO with a total of 22,000 tonnes topsides, allowing her to achieve a capacity of 150,000 bpd of oil. Her storage capacity is 1,600,000 bbls crude oil. The vessel will be installed on the Sapinhoás field (Partners in Block BM-S-09: Petrobras, BG, Repsol) in a water depth of 2,140m.

Ilhabela is Brasa’s first project and the ten modules that were constructed in the yard weigh over 13,000 tonnes. Three additional modules were constructed and delivered by EBSE, a yard that SBM works closely with as part of further development of dependable local content solutions. Last year also saw the successful delivery of Brasa’s Heavy Lift Barge crane, Pelicano 1, the highest capacity barge crane in Latin America allowing the yard to carry out module lifts.

The goal of ensuring that Ilhabela’s construction runs as smoothly as possible has significance far beyond this single project: the next pair of SBM’s ‘Generation 3’ FPSOs under way in Brazil will be “carbon-copies” of the vessel. FPSOs Cidade de Maricá and Cidade de Saquarema are due for delivery at the end of 2015 and early 2016 respectively.

Out of the current fleet of fifteen FPSOs, SBM currently has nine FPSOs allocated to Brazil (six producing and three under construction, all with substantial local content levels), making the company a vital player in the country.
Module lifting done in-house

The lifting of the 13 modules onto FPSO Cidade de Ilhabela was completed at the end of March 2014. The vessel was turned twice in order to load onto both the starboard side and the port side. The sequence had to take into consideration the degree of mechanical completion of the modules and also to have a larger clearance on one side during the lifting process. The first module lifted was the sea water treatment module (TS-021), which was built by Brasa.

The heaviest module is the CO2 Gas Compression (TS-073) with 2,332t, which was lifted in 3 sections. The heaviest lift undertaken by the crane was the Main Compression B module (TS-072) weighing over 1500t.

Final stage for 2014 delivery

Once ready the FPSO will leave Brasa to go to anchorage for sea trials and preliminary acceptance, followed by sailing to the final destination and performance of the 72-hour production test, leading to final acceptance. The start of operation is expected in the second half of 2014. SBM will operate the FPSO on the Sapinhoás field offshore Brazil under a 20-year lease contract for Petrobras.

Vessel details:

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Progress update on the twins

The twin FPSOs Cidade de Maricá and Cidade de Saquarema are also undergoing refurbishment and conversion work at the Chengxi (CXG) yard in China, the same yard that successfully completed the equivalent scope on Ilhabela. The execution plan for the twins will mirror Ilhabela in terms of transfer to the Rio yard at Brasa where integration of the hull and topsides will take place.

The double-hulled vessels will be moored in around 2,300 m (7,546 ft) of water. Their 22,000-ton topside facilities will be able to process 150,000 b/d of well fluids and have associated gas treatment capacity of 6 MMcm/d (212 MMcf/d) to be produced for reinjection and exported via submarine pipeline.

Phase 1: Asian Scope

Module fabrication is well advanced, vessel refurbishment and conversion for the two vessels is on-going and engineering is on track for completion.

Phase 2: Brazilian Scope

The Brazilian scope includes the fabrication of nine topsides modules per FPSO, the module integration and finally the completion and commissioning of both FPSOs. Like Ilhabela the fabrication of the modules is executed at the two Rio construction yards, SBM’s own yard Brasa and EBSE, with a high focus on engineering and supplying “carbon copy” design, materials and equipment, while integration, completion, and commissioning will be at the Brasa yard. Close liaison with the Rio office takes place on all aspects from engineering, supply chain, project controls, to construction. The Brazilian construction team is being mobilized and structural steel pre-fabrication and assembly are on track. Special pipe support and spool fabrication have commenced at both yards.

“March saw the one-year milestone since the signature of the LOA for Cidade de Maricá and Saquarema and excellent progress has been made. The project teams have delivered outstanding quality work with a strong focus on safety, quality and schedule,” says John Perkins, Project Director.

Twins at a glance

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SBM’s JV construction yard is achieving global standards and is proving a rewarding investment for both SBM and Angola.

It’s remarkable how within only five years a wild expanse of beach has been transformed into a world-class fabrication and integration yard and a thriving hub for a community. The timing for Porto Amboim Estaleiros Navais Limitada - known as Paenal yard - is perfect. Angola is the newest player in pre-salt oil and gas exploration, with offshore blocks indicating a similar potential to the vast hydrocarbons reserves of Brazil. The Angolan government banks on the success of its pre-salt blocks to nearly double oil output by 2020. Paenal will no doubt play a significant part in Angola’s future.

Recent events are placing the young shipyard on the world stage and it has already seen its first FPSO berthed at quayside with the second expected by the end of summer. Last year the yard completed its scope on FSPO CLOV due to start operating offshore Angola, for Total, this year. The yard had the additional honour of hosting the vessel’s naming ceremony in December 2013, which saw key members of the Angolan government, the National Oil Company and the oil and gas industry in attendance; this represented Angola’s first ever FPSO naming ceremony. Among Total’s guests were the yard’s three joint venture partners: CEO of Sonangol, Dr Francisco de Lemos José Maria, CEO of SBM Offshore, Bruno Chabas and CEO of Daewoo Shipbuilding & Marine Engineering (DSME), Mr. Jaeho Ko.

Paenal now enjoys international recognition as a strategic development in the country’s oil and gas industry. It was fitting that French giant Total celebrating its 60th Anniversary in Angola, gave the young yard a start in the industry. Paenal’s key position as Angola’s only offshore fabrication and integration shipyard is clearly on the radar for the major players.

“The successful completion of the FPSO CLOV project with an exceptional safety record is proof that the yard can deliver results. Paenal is becoming a thriving hub; its importance to the industry and Angolan communities is clear. The team is ready to tackle the next big project, N’Goma. We look forward to welcoming her quayside very soon,” says Jean-Philippe Rodrigues, SBM Offshore Business Development Senior Vice President.
The yard’s origins

Turning back the clock, the past 20 years had seen Angola transformed by its offshore resources to become one of Africa’s top oil producers. But the Kwanza Sul coastal province was not tapping into the strategic potential of its shoreline close to offshore pre-salt oil discoveries.

The inauguration of the Paenal shipyard in 2008 changed that, providing an ideal base for deepwater exploration in West Africa as well as creating for Angola an offshore services capability and ensuring prosperity for local people.

“Back in 2007, SBM and our partner Sonangol had a revolutionary vision: to create a state-of-the-art offshore fabrication yard in Angola. The successful realization of the yard and the positive effect it has on the country’s oil and gas industry as well on the local community keeps us motivated and along with the support of DSME, the third partner, we continue to strive to develop the yard’s full potential and to grow its personnel. The relationship between the joint venture partners is a mutually beneficial and respectful one. We are aligned in our goals and how to achieve them,” says Jean-Philippe Rodrigues, SBM Offshore Senior Vice President Business Development.

Cesar Guerra, the yard’s General Manager adds, “Paenal was established to meet Angola’s vital need to develop manufacturing technology and to facilitate the integration of FPSO modules.”

The region of Kwanza Sul was chosen for the excellent location, close to Porto Amboim, for the availability of local labour, and the support of the local authorities. In addition, the scale was ideal – with a spare 10 hectares adjacent for future expansion.

The plan was to create a hub; to attract other businesses and support services and so foster growth for the community - in part by Paenal giving preferential consideration to local suppliers. Among the companies to set up operations in Port Amboim since the yard opened are Friedlander Angola, Conduril - Engenharia S.A., Heerema Marine Contractors, PANALPINA, PIC and others - proof that the yard is the catalyst for development.

The knock-on effect of a stable source of work for a vulnerable community has profoundly transformed not just the workers but the livelihood of entire families and local businesses that live to the rhythm of Paenal. The yard is the biggest employer in the region with a workforce of over 1,200 employees; its employees are aware of the turnaround in their personal prospects as a result of investment and training.
The transformation of the yard has required the patience and vision of three partners SBM, South Korea’s DSME (since 2010) and the state-owned national oil company Sonangol, with respective holdings of 30%, 30% and 40% in Paenal. The joint venture set out to provide for the community in step with the yard’s development. One key issue was providing employment for a disadvantaged generation following over 35 years of civil war. Finding the required skilled workers locally who met international standards required initiative and investment by SBM – which brought to bear its essential yard start-up experience.

Applying the same successful formula in Angola, talented personnel who lacked experience were swiftly brought up to speed with on-site training undertaken by SBM personnel brought in from around the world. In parallel with construction of the yard, a dedicated training school was established in Porto Amboim town for local residents. To date over 600 workers have received training to ensure they meet the international standard set by Paenal’s founders. The effort and investment have produced results; Paenal yard picked up the prestigious Oil and Gas Year accolade Fabricator of the Year in Angola in 2012.

Having a stake in the yard also means that SBM fulfils its local content objectives. In addition, it allows for tighter quality control. SBM Offshore Yard QA & HSSE Manager, Romain Aubry de la Noe says, “Strategic partnerships with yards give us assurance that our engineers’ designs are followed to the letter and that SBM’s quality and safety standards are observed during construction.”

Furthermore, the Paenal yard will reinforce SBM’s opportunities for strategic expansion in Angola.

Shipyard capabilities and facilities

Today the yard is capable of producing up to 10,000 tons of modules per year, which represents approximately two million man hours per annum. Last year’s addition of the Heavy Lift crane has further transformed the Paenal yard’s capacities and filled a gap in the regional market. Combined with Paenal’s 490-metres, purpose-built quayside, the yard is fully commissioned and can accommodate the fabrication and installation of topsides into mega FPSOs. There are plans to invest in new equipment to further enhance the yard’s facilities and capacity for even heavier topsides.

OPS is a 50:50 joint venture between SBM and Sonangol with ten years of operations of FPSOs for Sonasing (a JV between SBM, Sonangol and private Angola companies). To date over 700 million barrels have been produced by the Sonasing/OPS fleet.
Today

The Angolan government is determined that the country’s transformation into an energy economy creates a sustainable future for its citizens and domestic industries. This was an integral part of Sonangol’s plan when they joined forces with SBM at Paenal. Since 2008, the yard’s workforce has grown exponentially. From a humble start almost 1,200 people are now employed, of which 85% are Angolan nationals - a level well above the 70% minimum set for the industry by the government. Paenal has now been operating for over five years and as a result of the experience gained, local employees are rising through the ranks.

Today SBM Offshore employs over 1,700 people in their Angolan operations (including Paenal staff) and has been established in the country since 1997.

Tomorrow

Paenal will soon celebrate the arrival of FPSO N’Goma, converted by SBM for Sonasing ahead of its relocation to an ENI operated field offshore Angola. The Sonasing-owned vessel is under a lease and operate contract with the operate part under the scope of OPS - both are joint venture companies between SBM Offshore and Sonangol. Following completion of the hull conversion and refurbishment as well as the integration of 85% of the modules at Keppel shipyard in Singapore, she will sail to the Angolan yard for the integration of modules built at Paenal. The yard has almost completed their construction in anticipation of her arrival.

The vessel’s 7,200 mile voyage to Angola will take an estimated 35 days with an expected arrival at Paenal in May. She will then undergo the final stage with the integration of two modules, which were fabricated at Paenal. The yard has almost completed their construction in anticipation of her arrival.

Mafumeira Sul Project

Paenal in consortium with DSME was awarded by Chevron the fabrication of two wellhead platforms (WHP) - 3200 metric tons each - destined for the Mafumeira Sul Field in Block 0. Expected to expend circa 1.75 million man hours up to December 2014, this project is a major project for the yard and heralds a major change to a higher level of technological development.

Work under the Angolan scope kick-started in May 2013 with the first steel cutting ceremony held at the Paenal Yard, marking the beginning of nineteen months of intensive fabrication activity.

N’Goma FPSO project background:

The N’Goma FPSO is the former FPSO Xikomba which was converted by SBM in 2002 and operated in Angola Block 15 for about 8 years by SBM Offshore’s Operations division. The FPSO was disconnected in 2011 and brought to Keppel Shipyards in Singapore for conversion to meet her new assignment.
It was a logical decision to think of SBM when the time came for BP to assess a project destined for the harsh environmental conditions of the North Sea; one that requires a combination of unique skill sets; turret mooring supply, field life extension, technology development and offshore contracting.

Market demand for turnkey mooring systems is strong at present, particularly for large, complex turrets, which are often located in some of the world’s most severe offshore environments. Due to their complexity they present many technical challenges and hence major oil players rely on the expertise and know-how of the likes of SBM Offshore, a world leader in mooring technology with over 50 turret mooring systems (TMS) under its belt.

SBM is supplying BP with a turret that will be one of the largest in the world, with a mooring force of 2,250 tonnes in the 100-year return environmental conditions, for the Glen Lyon FPSO. The vessel is currently being constructed in Korea for the Quad 204 project.

The turret is based on SBM’s proprietary bogie-bearing design and represents the third in a series of large turret mooring systems for BP for North Sea & Atlantic Frontier locations. It is the most complex turret SBM has supplied to the oil and gas industry to date.

SBM chose the Dyna-Mac yard in Singapore for the turret’s construction. Following over two years of work, the sections of the turret (bogie support structure, lower turret and collar, manifold and gantry) have been successfully completed. They were loaded out...
separately and sailed to Hyundai Heavy Industries yard in South Korea, where they are now being integrated into the Glen Lyon FPSO, a process which will last until the end of 2014. The next important milestone is the mechanical completion of the integrated turret in Korea, which will be managed by BP with the assistance of SBM Offshore, followed by the commissioning activities.

BP is upgrading the production facilities on the UK Continental Shelf (UKCS) Schiehallion field by replacing the existing Schiehallion FPSO with the Glen Lyon FPSO, which is to be moored in the same location using a new anchoring system. The turret weighs more than 10,000 tonnes – the heaviest ever delivered. The turret measures 94m in height – about the same height as Big Ben, the London landmark – representing more than a 50% increase on the height of the Schiehallion turret. It will host significantly more equipment and have a larger through-put while the weathervaning transfer system for fluids (oil production, water for injection, gas, various chemicals), power (electrical and hydraulic) and signals (electrical and optical) will be enabled by the world largest swivel stack (14 swivel units, about 265 t and 26 m high).

Glen Lyon FPSO will be located in 450 m of water depth, west of the Shetlands Islands where severe environmental conditions are challenging from a mooring viewpoint with extreme design sea-states and high fatigue loading.

Thanks to the Schiehallion experience gained over the past 15 years, the design maturity of the mooring line components such as steel wire rope and chain is high in this hostile environment.

Changeover from Schiehallion to Glen Lyon

The Schiehallion FPSO was decommissioned in 2013. The new FPSO will be a new-built, double hulled vessel of 270m length (b.p.) fitted with the SBM supplied turret designed for the harsh weather conditions and continuous operations west of the Shetlands. The turret meets the latest UK standards as well as BP’s specific upset conditions such as the loss of one mooring line in 1-year return environmental conditions.

The new turret design will provide adequate space for process sub-systems and provide utility support for the subsea control system. The turret will comply with a reduced mooring offset envelope for more onerous specified weather conditions, with the existing riser arrangement and new overall subsea production system layout. This includes design requirements for up to 28 riser slots – an increase of four compared to the Schiehallion FPSO - and for the anchor legs to be grouped into four clusters of five mooring lines each to suit the existing subsea infrastructure.

The arrangement of the turret system will allow anchor lines and risers installation to be diverless – an enhanced safety feature compared to previous designs. The turret structure has been designed for a minimum 25-year service life. In the course of the operations, swivel seals may require

Looking ahead beyond Quad 204

Future Atlantic Frontier developments will be further west in deeper waters presenting new challenges to the industry. The combination of deep water (more than 1,000 m) and the extremely harsh environment represents a world first for the mooring industry, requiring tailored modifications. For example the wire rope component will have to be replaced by polyester rope to enable the challenging design of a mooring system. Although such polyester ropes have been used for over 10 years in the deep waters of Brazil, the conditions are significantly less stringent in Brazil compared to the area west of the Shetlands Islands.
The scope for SBM Offshore covers the engineering, procurement, construction, transportation of the turret modules including the swivels, mooring lines and suction anchors on one hand and the disconnection / removal of the Schiehallion FPSO and installation of the new anchoring / mooring system and new FPSO hook-up on the other hand.

change-out, which will be possible in-situ thanks to SBM’s technology, without removing any swivel from the stack and without interruption to production.

In addition to handling the full crude production, water injection and gas lift / export / import flows, the swivel system will provide for all ancillary services required on the turret fixed part, including electric power and control, chemical injection, water deluge and air for Turret Equipment Room pressurization.

Turret enhancements since Schiehallion
The key enhancements of this turret mooring system are safety standards based on systematic in-depth analysis and improved reliability for operations. Some examples of these improvements are the riser top-mounted ESDVs and wind shielding, which could no longer be just one complete structure due to the increased size of the Quad 204 turret. Improved operability and reliability aspects are key design drivers to improving technology. The mooring force increased due to the larger size of the vessel and larger safety factors which contribute largely to a higher reliability.

Bringing added value
As to the installation of the new mooring system in Q2 2014 and the hook up of the new FPSO in 2015, the close interfaces between SBM’s teams allow for optimisation of both the mooring system and turret ergonomics. It also facilitates the interfaces for delivery of mooring equipment and readiness of the installation spread. The turret design is interrelated to the mooring design and to installation requirements (from the pre-tension of the anchor points up to the hook-up of mooring lines as well as requirements for maintenance and/or change-out).

Conclusion
At the top end of the market, the requirements of complex mooring systems such as the Quad 204 turret are continually being extended due to deeper water, more severe weather conditions, larger vessels to be moored, higher throughputs, increased pressures and longer design lives. SBM continues to lead the industry to adapt and tailor solutions for safer and more efficient operations offshore.
The sole intention of this brochure is to share general information.

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