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MacGregor Newsletter

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Photo: Roar Lindefjeld Woldcam - Statoil - Hywind Scotland

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Specialist mooring solution secures first floating wind farm

After six months in operation, the world's first floating wind farm, Hywind, is performing above expectations according to owners Statoil. It is achieving an average capacity of 65 percent – in comparison with typical capacities of between 45-60 percent for fixed offshore wind farms – despite one hurricane, one winter storm and wave heights of up to 8.2m.

Located 25km off the coast of Scotland, UK, Hywind's five 6MW wind turbines provide enough electricity for 20,000 homes. Designed to demonstrate cost-efficient solutions that enable the commercial capture of wind energy in deep-water environments, the pioneering project is held in position by Pusnes mooring connection systems from MacGregor.

MacGregor developed a fairlead chain-stopper system for Hywind with special features to prevent mooring line fatigue induced by out-of-plane bending (OPB). Also, as the system does not use any winches to 'pull-in' and deliver tension on the spar, pre-tension was achieved by externally pulling the mooring lines with anchor handling vessels.

Crane retrofit enables precision load handling to and from wind turbines

For offshore operators looking to enhance the capabilities of their MacGregor subsea cranes, including the ability to transfer loads to and from offshore wind turbines, then the MacGregor 3D Motion Compensator (3DMC) is an ideal solution.

It can be retrofitted to the knuckle-jib of an existing MacGregor subsea/offshore crane or specified on a new one, enabling owners to bid on a wider range of contracts as the crane has greater load handling capabilities.

The 3DMC compensates for the roll, pitch and heave motions of a vessel to minimise any movement of the load in relation to a fixed point in space. It can be easily installed and swiftly transferred to a crane with the relevant fittings, allowing it to be shared within a fleet. When not in use, the compensator can remain fixed to the side of the crane's knuckle-jib to allow full operational use of main and whip winches.

Safe personnel transfer in heavy seas

MacGregor has applied its three-axis, active heave-compensated technology to personnel gangways, ensuring the safe transfer of personnel in extreme sea states. The standard gangway features three compensating motions; however the system can be upgraded to include further active heave-compensation on the gangway's pedestal for managing extreme motions in high sea states.

Compensation systems include active, passive or combined control methods. A variable-height telescopic pedestal for operations exposed to tidal conditions is also available. The gangway can be delivered with or without an operator cabin and a lift. ■

Alvheim's Pusnes offloading has contributed to the production of about 370 million barrels of oil

10 years of regular service

behind over 1,000 offloading successes

After a decade in service, the Pusnes offloading system installed on Aker BP's *Alvheim* floating production storage and offloading vessel has completed over a 1,000 offload operations, underlying this successful track-record is regular maintenance

Every year, for ten years, service engineers from MacGregor's Global Lifecycle Support competence centre in Arendal, Norway, have undertaken a thorough inspection of the entire Pusnes offloading system installed on the *Alvheim* floating production storage and offloading (FPSO) unit.

This regular service strategy has paid off, with the FPSO having completed over a 1,000 offload operations and played its part in the production of around 370 million barrels of oil to date.

Operated by Norway-based Aker BP, the FPSO serves the company's Alvheim field in the North Sea, which experiences water depths in the region of 120 to 130m. "Since production began in 2008, *Alvheim* has produced oil beyond expectations, and there has been a gradual increase in developing the resources in this field," says **Frode Rydningen,** Marine Leader, *Alvheim* FPSO.

No stops, no problems

"The offloading system was commissioned and ready for use in 2008 and it has successfully performed at least a 1,000 offloading operations without any stops in production or any offloading problems," highlights **Egil Rose**, Service Manager, MacGregor.

"Our job is to continue to focus on delivering the safe, reliable and efficient operation of Aker BP's Pusnes offloading system and its uninterrupted operational availability is of great importance," continues Mr Rose. "This is reflected in the high-quality expectations that the company places on service and maintenance, and our work on the *Alvheim* FPSO is no exception."

Aim for gold

Regular, expert maintenance ensures that equipment operates efficiently, at peak capacity and that any issues are rectified well before they pose a problem, for example impacting on a vessel's availability. It also ensures that a vessel can maximise its earning capabilities and reduce the lifetime cost of equipment.

"Annual inspections pay for themselves many times over, as companies that choose this proactive approach to service rarely experience any problems," says **Trygve Risdal**, Service Engineer, MacGregor. "Operators know that their systems have been examined by skilled, trained personnel from the original equipment manufacturer (OEM). This is the 'gold-standard' for service, and it shows." ■

Annual inspections pay off

A thorough inspection of the Pusnes offloading system installed on the *Alvheim* FPSO vessel includes all MacGregor Pusnes products, including key elements such as the:

- offloading hose reel with crude hose
- hawser-handling winch with emergency release system
- control system with interlocks and safety system
- hydraulic power unit
- 20" emergency shutdown (ESD) valve and interconnected products.

Alvheim FPSO fact file

- Oil can be offloaded in storm conditions at maximum wave heights of 10m.
- Crude oil flows at 12m/s inside a 0.50m diameter hose, providing a maximum offloading rate of 5,200 m^3/h. This is equivalent to 1,444 litres per second.
- Loads are transferred from the FPSO's centre tanks and pumped through a fiscal measuring station before running through an offloading hose from the FPSO to a shuttle tanker. The FPSO is ballast-stabilised using seawater.

Combined expertise cuts wind turbine installation times

A new monopile installation solution, developed between MacGregor and Kongsberg Maritime, eliminates unnecessary temporary mooring, offering substantial savings to the offshore wind energy market

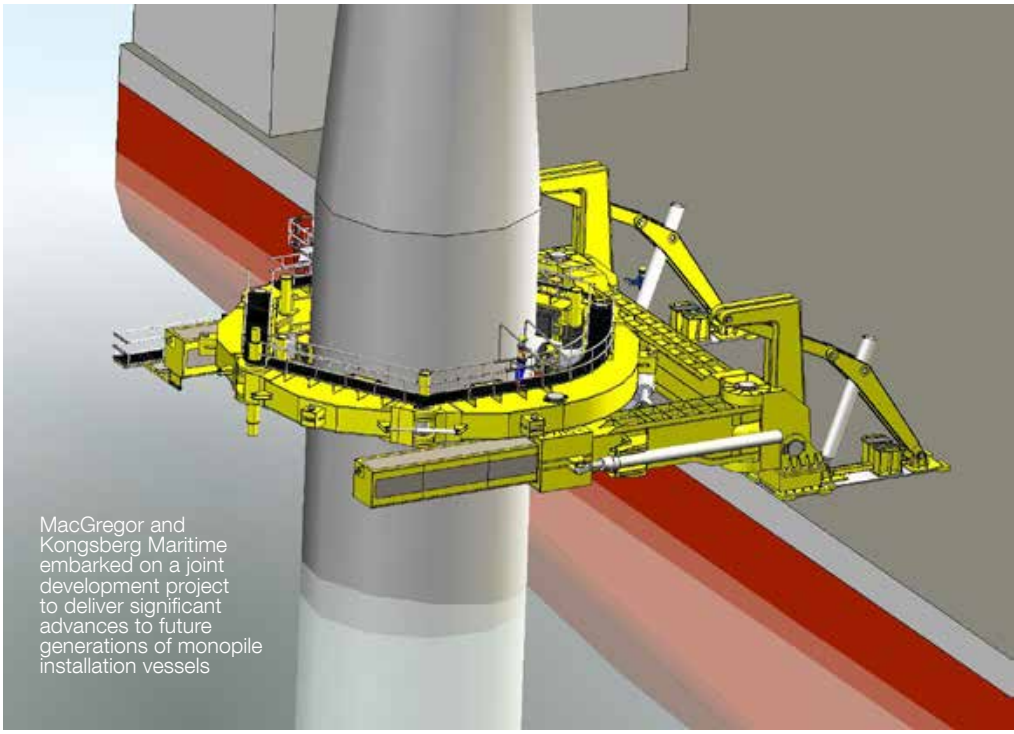
The offshore wind farms under development today are moving to more remote locations and increasing in capacity and size, bringing with them a host of new challenges. The biggest of these is created by a vast increase in the weight and height of turbines. This has driven the demand for a new-generation of monopile installation and maintenance vessels designed to cope with the industry's future developments and needs.

Monopile installation vessels have traditionally been jack-up units and to some extent moored floaters. However, as foundation sizes have increased, jack-ups are predominantly used. They typically employ pile-grippers on static frames, with complex mooring arrangements to hold the pile steady until it can be securely and permanently fixed to the seabed.

"A pile standing on the seabed will self-penetrate to a certain level, but it is not stable," explains **Kristina Arutjunova**, Director Sales and Marketing Innovations, Advanced Offshore Solutions, MacGregor. "Wave forces can be considerable, therefore the pile must be held still by a guiding frame on the vessel until it is driven down to a stable position. If the vessel is moored very securely, and the sea state is calm, a traditional pile-gripper, fixed to a static frame, can be used. However, these ideal conditions are often not seen offshore."

Market-ready technology

Recognising this gap in the market and the need to offer operators a new monopile installation method that benefits from the latest automated solutions, MacGregor and Kongsberg Maritime embarked on a joint development project. Its aim was



MacGregor and Kongsberg Maritime embarked on a joint development project to deliver significant advances to future generations of monopile installation vessels

to deliver significant improvements in the operability, productivity and efficiency of future generations of monopile installation vessel fleets.

Both companies believed that substantial cost and time savings could be captured by applying motion-compensation technology, coupled with dynamic positioning (DP), to the monopile installation process. This resulted in the development of a new pile-gripper solution, which is now ready for the market.

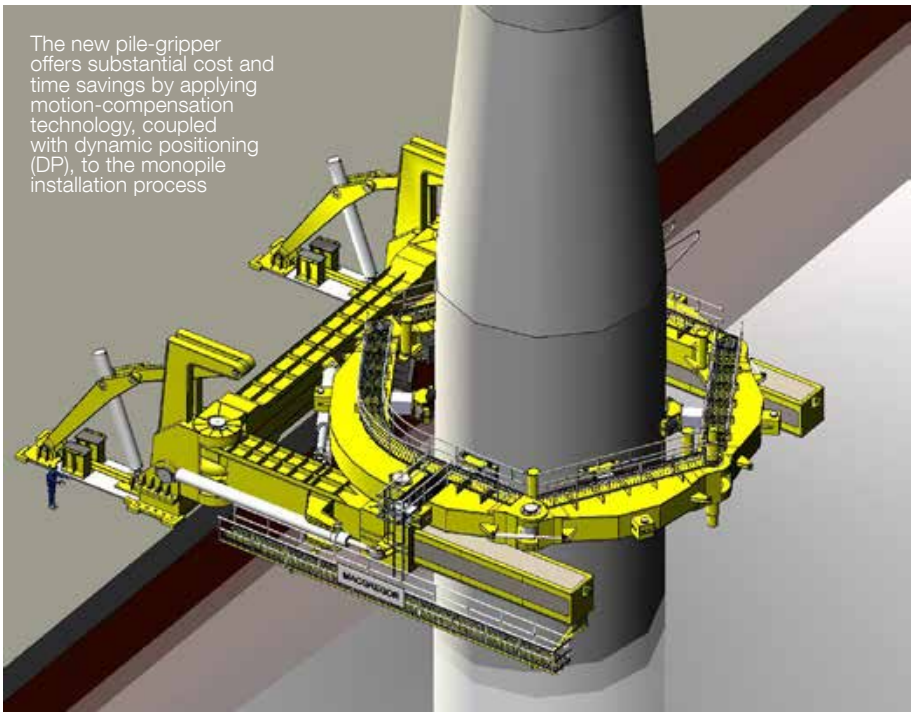
"We have developed a core solution that tackles the efficiency of turbine and foundation installation vessels by replacing lengthy, temporary mooring processes with full DP in combination with an innovative guidance system and hydraulic frame mechanism," says **Gunnar Thorsen**, Executive Vice President Business Development, Kongsberg Maritime.

Wider operational windows

"Our newly-developed pile installation method represents a considerable improvement over traditional methods," Ms Arutjunova continues. "Piles can be installed in a wider range of sea states and operators are not longer constrained by waiting for ideal weather windows.

"Essentially, the motion-compensated pile-guidance frame ensures shorter installation times and increases operational weather windows, adding up to substantial cost savings.

"We are confident that the capabilities offered by this new system will meet the developing needs of the offshore wind energy capture market, especially as it addresses the fundamental issue of handling these larger turbines, but also the need to install a greater number of them more quickly and further offshore," she concludes. ■

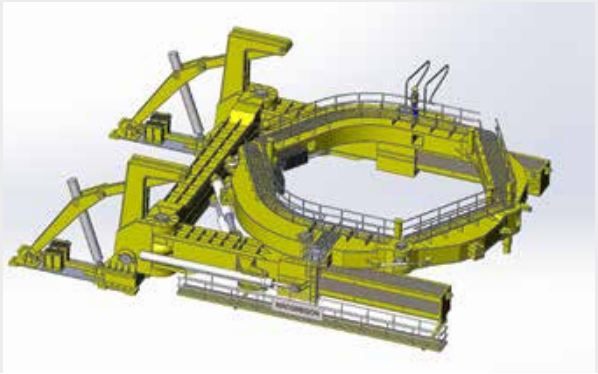


The new pile-gripper offers substantial cost and time savings by applying motion-compensation technology, coupled with dynamic positioning (DP), to the monopile installation process

A new monopile installation method is now available

The jointly-developed new pile-gripper solution consists of the following components:

- Motion-compensated, hydraulically-operated pile-gripper: provides a precise, responsive and powerful hydraulic frame mechanism for holding monopiles in a vertical position in open seas
- A pile-gripper guidance control system: this works in tandem with the high-precision DP system and provides a coordination link between the pile-gripper and the DP system
- A pile-gripper servo control system: this translates vessel motion and monopile position data to movement in the actuating cylinders. It also monitors loads and the status of the pile for feedback into the guidance system.
- Abandon monopile capability: if there is a loss of position, the monopile is guided into the last possible position, and then the gripper is opened for abandoning the pile.



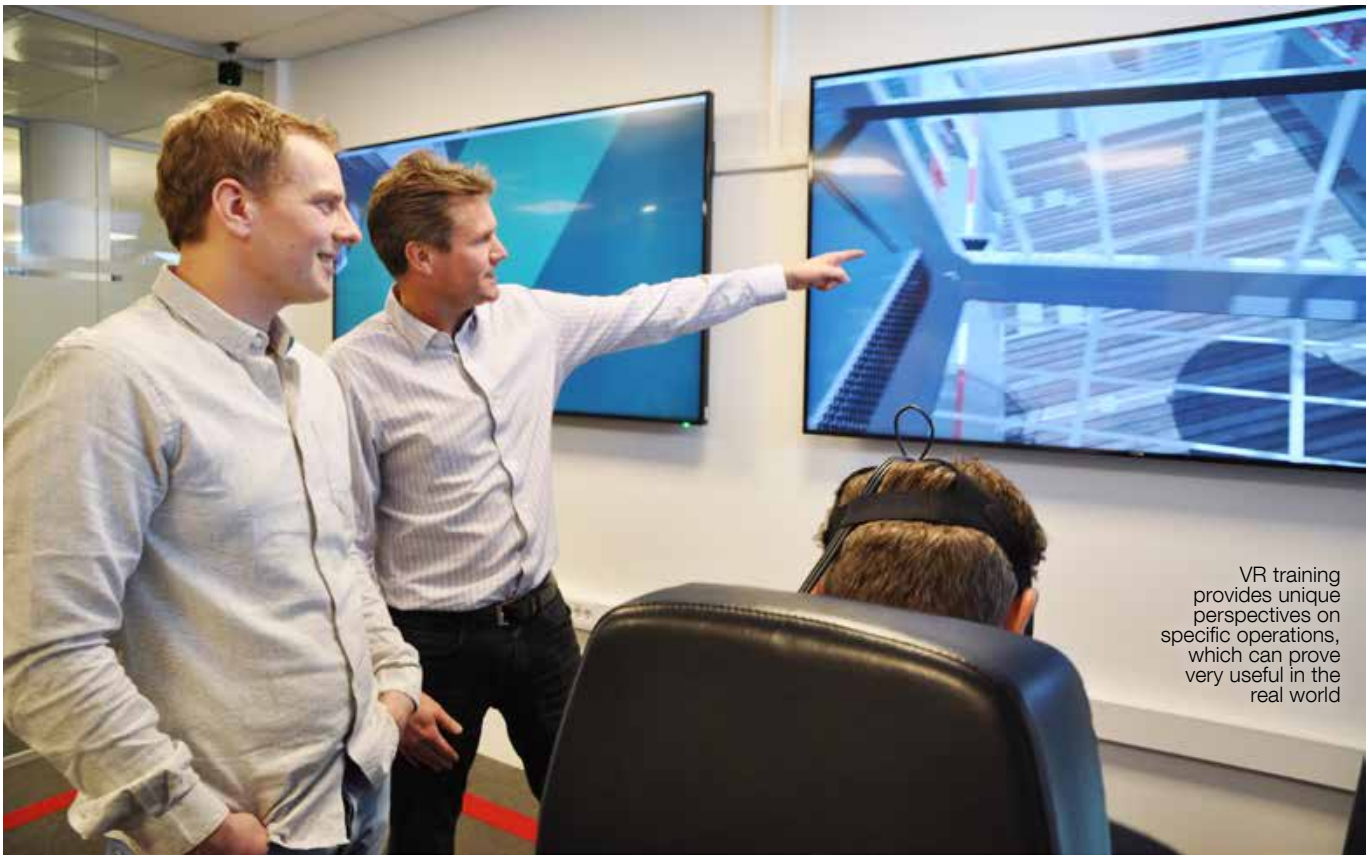
A precise, responsive and powerful hydraulic frame mechanism holds monopiles in a vertical position in open seas

Continuous crew training **cuts risks and drives efficiency advances**

Sophisticated offshore technology is designed to improve safety and efficiency, good reasons why training crews to use it effectively is beneficial; recent uptake in MacGregor's tailor-made training programmes shows that operators agree

Following an extended period of readjustment, it seems that the oil and gas industry is turning a corner. Its protracted economic difficulties have put enormous pressure on operators, evidenced from the major moth-balling of projects to relatively minor belt-tightening strategies, amongst which training and maintenance are often two of the first targets. Their impact on safety is undeniable.

Tailor-made programmes from MacGregor ensure that operators receive exactly the training they require



VR training provides unique perspectives on specific operations, which can prove very useful in the real world

There is a widening call for a more global approach to offshore safety. According to European Commission (EC) figures, there are currently over 1,000 offshore oil and gas operations in European waters alone. It states that accidents, even historic ones such as the 2010 *Deepwater Horizon* disaster in the Gulf of Mexico, illustrate the need for comprehensive safety measures.

Liability is at an operator's door

Safety remains the primary responsibility of operators and individual countries, but an accident in one country can cause environmental and economic damage to neighbouring ones. The EC's Safety of Offshore Oil and Gas Operations Directive and similar globally adopted legislation place liability for offshore accidents firmly at an operator's door.

Efforts to reduce the likelihood of these incidents have habitually focused on maintenance and environmental factors such as faulty equipment and adverse weather conditions. Today, prevention measures are increasingly recognising human factors as a key challenge to offshore safety and performance, which is where ongoing training plays a major role.

> "A crew that knows how to operate equipment in all situations, especially an emergency one, is also a safer crew"
>
> Mikko Lehtinen

"Behind every offshore service today is a crew operating some the industry's most sophisticated technology in existence, and they do so remotely, often in extremely harsh conditions," says **Mikko Lehtinen**, Vice President, Global Technical Support, MacGregor.

"These innovations offer the potential to drastically reduce the impact of human error and machinery breakdown, and optimise efficiency," he continues. "High-quality training secures the proficient use of this equipment, which incidentally prolongs its service life, reduces maintenance costs and dictates the safety of any operation; all good reasons why operators should train crews to use this technology well.

"Our priority is to transfer knowledge about safe operations and opportunities to maintain and operate equipment correctly," Mr Lehtinen notes. "Crews who know how to operate equipment safely and systematically will prevent failures and help protect the environment.

"A crew that knows how to operate equipment in all situations, especially an emergency one, is also a safer crew."

Ongoing crew training is beneficial

However, it is not simply the training that is received during hand-over and commissioning that is important, it is the ongoing commitment by an operator to train progressive crews that fundamentally affects safety.

"Bad habits can be passed on from crew to crew," stresses Mr Lehtinen. "We believe that ongoing good-quality crew training is as essential as good maintenance regimes and we are not alone in this thinking. Offshore operators are stepping-up to their training responsibilities.

"Most recently our latest tailor-made course for offshore loading operations was completed by crew working on Statoil's *Aasta Hansteen* spar platform in Norway. Also in Norway, tailored offshore mooring and loading courses for crew on oil platforms have been completed. Additionally, we have recently conducted specific operational and maintenance courses on offshore mooring equipment used on spar platforms in the Gulf of Mexico. The uptake of these tailored training services is positive news for the sector as a whole."

Reinforcing a safety culture

As offshore technology continues to develop, crews will be less able to depend on inherited knowledge and intuition to guide decision-making. Instead, a sound basis is necessary for assessing human performance; crew members need to understand the reasons why mistakes occur and apply lessons learned. "Going forward, a strengthened and sustained safety culture within the offshore industry will depend on effective crew training," Mr Lehtinen concludes. ■

Simulation-based training increases crew competency

In 2017 MacGregor opened a specialist academy dedicated to providing advanced training for both customers and its own personnel. It is designed to meet a growing need to deliver training packages proportionate to the sophistication of technology used in the offshore industry. It also enables customers to explore and test a product's capability before production begins.

Located in Arendal, Norway, the academy has a purpose-built virtual reality (VR) showroom.

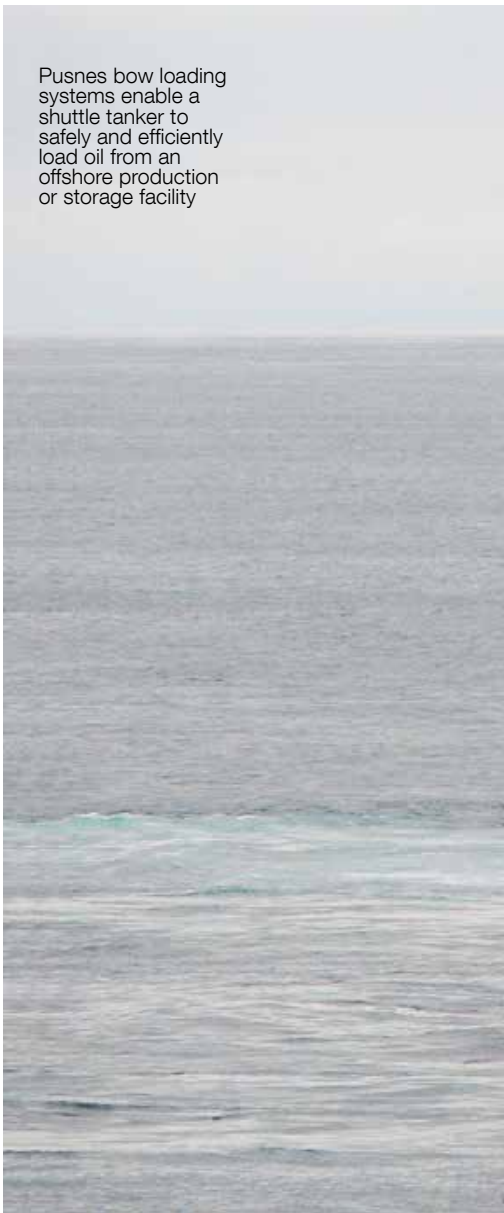
"VR training means that you can explore restricted, dangerous areas that you wouldn't normally be allowed to enter," says **Jan Finckenhagen**, Training Manager, Offshore Mooring and Loading Equipment, MacGregor Training Academy. "This provides otherwise unobtainable perspectives on specific operations, which can prove very useful in the real world.

"Our aim is to help customers use their equipment safely and efficiently," he continues. "Training using fully-immersive techniques delivers extraordinary benefits. Crews can repeatedly practice specific operational procedures, significantly reducing the likelihood of causing injury to personnel or damage to equipment because they have already tried and tested them."

VR headsets deliver realistic 3D visualisations, which enable users to view very small details of an operation, as well as the wider picture. The headsets are linked to large, wall-mounted screens, aiding the training process by allowing instructors to observe exactly what the user sees. "It is a very convincing experience," adds Mr Finckenhagen.

The academy is now the simulation training hub for all MacGregor offshore cranes, offshore mooring and loading systems, as well as deck machinery and steering gear. It offers product-specific courses including theory, operation, maintenance, trouble-shooting and manual training across MacGregor's entire product range and expects up to 100 users a year.

Delivering significant improvements over previous versions, the 5th generation Pusnes bow loading system offers wider operating parameters to ensure success where traditional systems struggle



Pusnes bow loading systems enable a shuttle tanker to safely and efficiently load oil from an offshore production or storage facility

New-generation bow loading system showcases improved connections

Continuing its commitment to refining the development of products that serve the offshore oil and gas industries, MacGregor now offers its 5th generation Pusnes bow loading system. Featuring greater hose connection capabilities than previous generations, the new system promises operators all the proven safety and performance credentials as earlier ones, but with a wider operating scope.

Bow loading systems (BLSs) enable a shuttle tanker to safely and efficiently load oil from an offshore production

or storage facility, such as a floating production storage and offloading (FPSO) installation. "Even with the advanced stability systems such as weather-vaning and dynamic positioning (DP2) in place, connecting two vessels in an open sea can be a difficult and dangerous business," says **Stein Are Andersen**, Sales Manager Offshore Loading Systems, MacGregor.

Increased operating opportunities

"The new-generation BLS system is capable of connecting the loading hose in wave heights up to HS 4.5m and at an entering angle of 110 degrees. This is 50 degrees more than our previous system," Mr Andersen continues. "Once the hose from the FPSO is connected to the bow loading system coupler valve, the whole system must deal with a sea's considerable rolling and yawing motions up to wave heights of HS 5.5m.

"The ability to connect at much wider angles increases operating opportunities in conditions where shuttle tankers would normally struggle to connect," he stresses. "Also, shuttle tankers can stay connected, even in sea states which generate wider relative angles to the FPSO, which traditionally would have meant that they must disconnect for safety and operational reasons.

"Together these deliver significant cost savings by improving operating times and connection speeds."

The latest generation system also features a handheld wireless remote control, which provides enhanced flexibility for the crew operating the system.

> The 5th generation Pusnes bow loading system delivers significant cost savings by improving operating opportunities and connection speeds

In addition to adhering to strict environmental responsibilities, shuttle tankers have to operate in extremely hostile conditions. The majority serve operations in the North Sea, offshore Brazil and the Arctic north of Russia. The 5th generation Pusnes bow loading system has therefore been specially designed to suit environmental temperatures ranging between +45 degrees to -20 degrees Celsius.

Efficient liquid cargo handling

The bow loading system consists of two integrated units, a hose-handling and hawser-handling system.

The hose-handling system comprises a 20" bow-loading coupler, located forward in the centreline of the ship. The coupler is connected to the Pusnes hose end valve from the offloading platform or the FPSO/FSO installation.

A vital part of the system is the Pusnes moment-free bow loading coupler, which allows the coupler to follow the movement of the hose. The system includes a hose winch for pulling in and handling the hose during the connection and disconnection phases.

The hawser-handling system includes an adjustable roller fairlead, a chain stopper and a twin-drum traction winch for mooring operations during tandem loading, all are located on the platform deck.

The chain stopper is hydraulically-operated and self-locking, and can be released under full design load. Aft of the chain stopper is a guide roller with a built-in load cell which operates together with a traction winch. The system also includes a storage reel or bin for storing the messenger line during loading. ■

5th generation debut

As the offshore oil and gas industry undergoes its tentative return to growth, FPSO projects are already restarting off Brazil and the UK, and in the next three years experts anticipate renewed activity in the South China Sea, North Sea, and the Gulf of Mexico.

Projects of the immediate future, will be designed to keep costs as low as possible and efficiency high. Even with fewer competitors in their own sector, operators in this field will be mindful of the competition they face from outside, from the US shale oil firms and elsewhere, and investing wisely to leverage the latest technologies.

These were the challenges facing MacGregor when, in a recent contract with Teekay Offshore Partners, it was called upon to redesign its shuttle tanker bow-loading system to fit Teekay's requirements.

Designed to fit Brazilian, Canadian and North Sea loading operations, MacGregor will deliver the design, fabrication and commissioning of the system on four of Teekay's latest shuttle tanker newbuilds. The vessels are under construction at Korea's Samsung Heavy Industries to Teekay's new E-Shuttle design.

The new Aframax tankers will incorporate many other cutting-edge technologies, including dynamic positioning (DP2) and the use of liquefied natural gas (LNG) as fuel in combination with clean battery power. The first two are scheduled for delivery by 2020 and are planned for deployment in the North Sea.

Collaboration targets critical mooring line analysis

As offshore energy production continues to expand into deeper waters, a joint research project is underway to develop methods to reduce the probability of mooring line failures in floating installations

LifeMoor is a great opportunity to use MacGregor's expertise in offshore mooring systems to reduce the probability of chain failures

The offshore mooring market is expected to grow to USD 1,766 million by 2024, according to the Global Offshore Mooring Market Overview report published by US firm Variant Market Research. This growth is a result of increasing energy demands, pushing the offshore oil and gas industry into deeper waters.

The offshore mooring systems securing these production units are designed to withstand significant environmental forces. However, over time fatigue and degradation factors such as wear, abrasion and salt water corrosion can dramatically reduce their load capacity and integrity. Floating installations have a unique set of challenges relating to mooring line wear.

Reducing failure rates

Considering this, MacGregor has announced its participation in a collaboration project with the Norwegian University of Science and Technology (NTNU) and the Foundation for Scientific and Industrial Research (SINTEF); Norway's largest independent research institution, to enhance the lifetime and design of mooring chains in offshore mooring systems. Other essential industrial contributors are also collaborating in the project.

Mooring line failures can have catastrophic consequences, but the combination of high costs and potential production downtime attracts hesitation when it comes to replacing them. The wide-ranging factors that contribute to their failure also make it difficult to assess the condition of system components.

The purpose of the four-year LifeMoor project, funded by the Research Council of Norway (RCN) and run by SINTEF, is to address the underlying causes of mooring system failures. It is also designed to improve the integrity of mooring chains by expanding industry knowledge about the effects of degradation and fatigue, and to assist the development of monitoring systems to assess the state of mooring systems in operation.

"LifeMoor presents a great opportunity to draw on our lengthy expertise in offshore mooring systems to reduce the probability of chain failures," says **Jon Hövik**, Technical Manager, Advanced Offshore Solutions, MacGregor.

"With SINTEF's knowledge and our most recent successful experience with the supply of Pusnes mooring systems to the world's first floating offshore wind farm, Statoil's Hywind project, in Scotland, UK, this collaboration could not have come at a better time."

Extended life expectancy

The Hywind turbines have a 20-year planned service life. "Our mooring systems played an integral role in their installation and now they hold them steady in the extreme conditions of the North Sea (page 2)," says Mr Hövik.

In addition to more reliable and cost-efficient mooring systems, MacGregor also expects that LifeMoor will offer better service life estimates on mooring chains, delivering a significant benefit to operators. ■

It is brave to be safe

It is not brave to take risks. MacGregor personnel take the time to double-check and make their decisions based on what is safe.

MacGregor has a market-leading reputation for safety. We identify and mitigate risk as a part of our daily work, in the office and in the field. We speak out if we have doubts and stop a job if it is not safe. Safety takes priority over all other considerations.

As part of our commitment to a safety culture our employees use a new safety app, delivering monthly safety updates and educational modules.

It is not brave to take risks; it is brave to be safe.

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