Vessel mooring & monitoring systems at offshore LNG terminals

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In response to balancing the issues of environmental concern, access to suitable land sites and the economic reality of getting gas to market within an acceptable timeframe, an increasing number of LNG terminals are being developed or studied for location offshore. Projects include gravity base structures, conversion of existing offshore platform facilities and the use of Floating Storage and Regassification Units (FSRU vessels). The approach and safe mooring of the gas carrier to the offshore terminal must consider not only all factors that affect a typical near shore jetty facility, but also increased sea state, access to and operation of the mooring equipment and relative vessel motions in the case of FSRU's.

The concept of a fully integrated Ship-To-Ship (STS) mooring system is a key component of offshore LNG terminal design. Integrated mooring systems are custom engineered, long lead purchases requiring independent testing and an ISO9001 accredited approach to design and manufacture. For the construction of the marine facilities to proceed smoothly, the earlier the specifications are developed, the better. There are however vast differences in features and the quality of standard jetty-based mooring equipment and careful selection is essential to ensure the safe and efficient mooring of the LNG carrier offshore. Development of the integrated system is ideally carried out by a specialist, full service supplier providing performance and capability input across the range of equipment to the design engineers starting at pre-FEED and beyond.

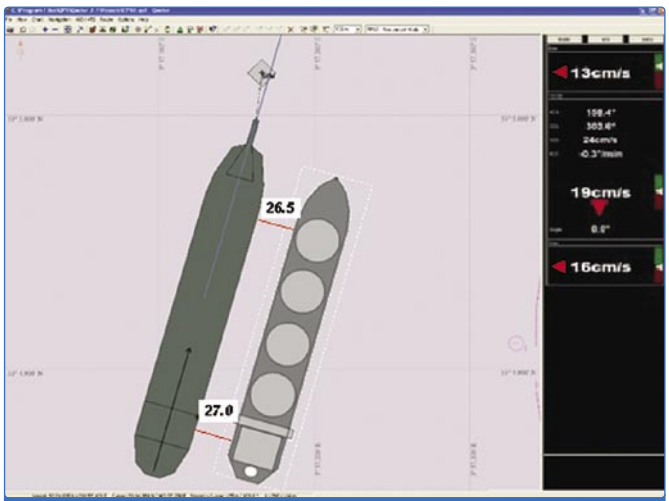
This article briefly addresses the design of mooring equipment and monitoring systems for offshore LNG facilities and how they are integrated to provide centralised data to the operators. The equipment is based on design philosophies used successfully in near-shore jetties and typically includes:

- Vessel Docking and Piloting Aid Systems
- Environmental and Met Ocean Monitoring
- Quick Release Hooks and Capstans
- Remote Release Systems
- Mooring Line Load Monitoring

Docking Aid and Piloting Systems

At near shore jetties, a laser Docking Aid System such as SmartDock® DAS measures vessel distance, angle and speed of approach using lasers mounted on the jetty. The data is used by the Pilot and vessel Master to assist in manoeuvring the carrier vessel safely alongside the terminal during the last 200m of approach and is displayed and logged at the central monitoring PC and also made available to the Pilot on a jetty mounted large display board or over telemetry to a handheld monitor.

The same equipment can be used offshore, however it is often complemented by measurement of carrier position via GPS. This is particularly important for application on floating terminals where the dynamic movement of both the FSRU and the carrier may reduce the practical range of the laser system to less than 100m. Here, a DGPS or RTK-GPS based piloting system can provide display on a carry-on laptop during approach and may interface with the laser DAS once the carrier is within a preset distance of the FSRU to provide increased accuracy and/or redundancy of approach data. Because the laptop communicates with the terminal over telemetry, all approach data can be logged centrally. In addition, environmental and sea state data may also be sent from the terminal to the pilot laptop providing a further layer of information to effect a safe berthing operation.



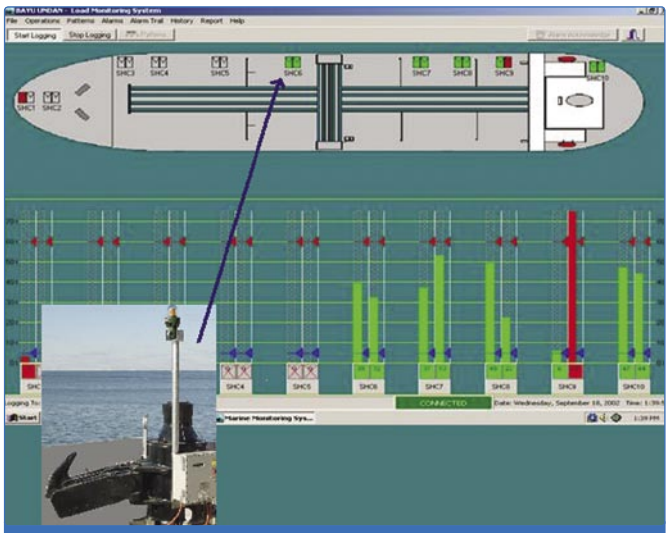
Screen view of GPS piloting/docking software.


SmartDock® PILOT-X GPS carry on unit.

Environmental and Met Ocean Monitoring

Wind, wave and current forces acting upon the vessel have a significant effect on vessel handling, particularly at slow speed and manoeuvring under tug assistance.

QRH unit for STS mooring on Bayu Undan FSO.



Bayu Undan LMS screen.

Offshore LNG marine facilities typically require additional environmental and oceanographic sensors in comparison to a near shore jetty, to provide valuable data during approach, docking and whilst alongside and enable both terminal and carrier personnel to make informed decisions on operations.

The data is collected from a variety of sensors such as:

- A weather station on the LNG terminal (typically including visibility linked to a fog horn).
- Current monitoring, both at the terminal/FSRU and in the approach route.
- Measurement of wave height, profile and direction data using a buoy or seabed mounted device.
- Monitoring of salinity, water temperature, and other sensors specific to each project.

The sensors communicate with the central PC over cable or telemetry and data can be relayed to the laptop carried by the Pilot.

Quick Release Hooks and Capstans

The Quick Release Hook (QRH) is the foundation of any integrated mooring system and is recommended by both SIGTTO and OCIMF.

Hook units are mounted on the LNG facility and provide the point of restraint between carrier and fendering. QRH's are typically of triple or quadruple configuration on a common support base. The units are designed to withstand static and dynamic forces exerted by the carrier from wind and current load, whilst alongside. As with jetty mooring equipment, we are seeing an increase in hook capacity to accommodate the projected increase in vessel size to 200,000m^3 plus, where 150 tonnes SWL capacity is now being specified.

The hook base incorporates a capstan used for hauling in each mooring rope to the hook. To provide greater protection from the marine environment and extend service life, the capstan motor should be fully enclosed within the base structure.

Recent innovations incorporated with latest generation of mooring hooks include:

- Extra mechanical features incorporated in the design of the hook unit, allowing faster connection and securing of mooring lines. Reduced mooring line handling means greater safety for mooring crews and reduced time to moor the vessel.
- Visible warning light stations at each mooring point allows the mooring crew to indicate to the carrier's crew when it is safe to tension up the mooring line using the ship board winches.
- Use of first line storage winches in place of capstans to ensure good quality first lines are deployed to the approaching vessel and also provides capability of hauling in the vessel's mooring lines and attachment to hooks.

Remote Release

Integral to most hook designs is a manual release mechanism. A Remote Release system however, provides the operator with the means to release each hook remotely from a safe location and without the need for operators to be present at each hook unit. Control employs digital communications using either a console or computer.

Release mechanisms generally include either Electric or Hydraulic operation. There has been a strong swing toward electric based systems, which offer the same level of functionally in terms of release control and safety, with substantially lower maintenance requirements.

In comparing equipment, designers should recognize that remote release is not a passive system and the accidental release of quick release hooks, and thereby the vessel itself, can lead to very serious consequences. The supplier must therefore incorporate appropriate interlocks and control protocols within the release system.

Mooring Line Load Monitoring

Once the vessel is alongside the offshore terminal and mooring ropes secured, line tensions and their distribution must be monitored effectively as this is the critical structural element which limits vessel surge (longitudinal drift) and sway (drift out). Measuring line tension is by way of load cells installed in the pivot block at the rear of each hook.

The efficiency of the mooring system is largely dependent upon layout, length of each mooring element, stiffness and construction of mooring lines. The management of the vessel's mooring system represents a great responsibility to both terminal operator and Master and requires considerable understanding of the factors discussed above, as well as effective information feedback in order to allow time to make the right decisions.

Therefore, in addition to display of load data in the jetty control room, it is recommended that mooring loads are available at each hook location, linked to a high load alarm siren and strobe, to alert jetty operators and vessel crew immediately a line becomes over-loaded. Corrective action can then be taken in timely response to changing conditions. This local, real-time display is also extremely useful in removing the guesswork during pretension of mooring lines to ensure loads are correctly balanced and the vessel is safely moored from arrival.

An integrated approach to central monitoring

All data from docking lasers & GPS, load cells and environmental sensors is relayed to a central PC system located in the facility's control room. Signal communications over RS485 and fibre optic provide a significant reduction in cabling requirements compared with just a few years ago; as example, Harbour & Marine's SmartHook® Load Monitoring system utilises this digital link, which may also accommodate remote release control.

Marine monitoring is a stand-alone system, dedicated to the vessel approach, mooring and cargo transfer operations window, with a customised user interface and proprietary integrated software. The data is often displayed on a portable monitor or laptop for use by the Pilot and Mooring Supervisor. Data is also interfaced with the offshore terminal's DCS over modbus or OPC protocols, and this data can then be transferred to the vessel over the Ship-Shore Link. SIGTTO recommendations for example, call for load monitoring data to be available at the vessel whilst alongside.

Conclusion

Mooring and monitoring systems for LNG marine terminals have undergone significant development during the past five years with a positive move towards fully integrated systems and one manufacturer responsible for the total design, supply and ongoing support. From the authors' experience, mooring systems need to be considered during project FEED and at each main design review to ensure specifications incorporate the latest technology and operational feedback and provide the LNG facility with the tools to effect safe and efficient vessel mooring.

Typical large display board.

ABOUT THE AUTHORS

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ABOUT THE COMPANY

Harbour & Marine Engineering (HME) is the leading designer and supplier of integrated mooring and monitoring systems to the oil and gas marine industry worldwide. The company has supplied equipment to over 65 per cent of LNG terminals over recent years utilising design experience from its combined in-house mechanical and instrumentation engineering teams. HME is part of the Trelleborg Group of companies and has a network of offices and agents in support of its international business.

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