SYNOPSIS: Assisting LNG carriers at offshore floating LNG terminals, presents a challenge to the tug industry. These facilities will require the agility and responses of a ship assist tug with the sea keeping capability of their much larger cousins operating in the offshore industry. This paper provides a review of some of the research carried out to date into resolving the challenges this concept and environment presents for tugs, crews and operators.

INTRODUCTION

Much of the proven gas reserves in the world are found in offshore fields, perhaps as much as one-third, or 60 trillion m³. Gas that is found offshore generally has to be brought onshore for its value to be realised. Thus, in all of the many offshore gas fields, whether non-associated or gas associated with oil production, it is processed to the extent necessary to pipe it to shore, where it can be processed to consumer specification and, ultimately, sold into the gas distribution network. But, what happens if your reserves are too far offshore or the route too challenging to make a pipeline economically viable? What then?

Offshore Floating Liquefied Natural Gas (FLNG) production and storage has been promoted by the oil and gas industry as one of the leading technology development areas for the future for some years. Paper studies for offshore LNG production have been performed, in varying degrees of detail, since the late 1970s. However, it was in the mid 1990s that substantial work backed up with specific experimental development was performed. These developments were motivated by a sustained world-wide rise in natural gas consumption, exceeding the growth of other fuels. Its current share of total primary energy consumption is over 25% and the increase in global gas consumption in 2004 exceeded the 10-year average rate and rose in every region.

The obvious imperatives for this research and development have been the perceived need to process and monetise associated, stranded and in some cases marginal gas reserves for various economic and environmental reasons. There was a time when LNG only played a speculative role in the development of offshore fields but more recently international accords, like the Kyoto protocol, coupled with the economic advantages of unlocking stranded gas reserves, has provided a renewed impetus to the concept.

Many of the most promising targets lie a considerable distance offshore in deep water where the weather can be anything but benign. Concepts to exploit these finds have faced many technological challenges – particularly in the areas of mooring and cargo transfer of LNG carriers to a floating structure; in reaching a point where it is generally accepted that the concept is feasible; albeit that some of the technologies are as yet unproven in a shipboard or floating application.

Despite this concentration on the subject, one area that has received, until recently, very little meaningful attention in developing these various concepts has been that of ship assist. Clearly, where the floating production unit is stationed permanently offshore and relies on a “standard” LNG carrier (LNGC) to export the LNG produced, an understanding of the limitations this places on a support fleet has to be developed and a methodology has to be established if berthing and un-berthing is to be carried out safely, as well as providing a safe working and living platform for the crews.

Floating LNG terminals are being proposed in open sea locations where generally the conditions are much more severe than close to the coast at a jetty or in shallow water where most receiving terminals or gravity based structures (GBS) will be situated. It is currently difficult to predict how tugs and their crews will perform in these conditions and therefore almost impossible to establish a quantifiable safe operating envelope.

In defining what is regarded as “severe” in the context of ship assist in open waters, it’s worth summarising the general observations of tug behaviour from the MARIN pilot study. The tests, it noted, confirmed the motions of the assisting tugs in waves are significant, even in wave conditions that are considered mild for the berthing and offloading of LNG carriers assisted by tugs. What resulted
were repeated slack tow line events and frequent high tow line peak load events in the pull mode coupled with very high peak fender loads in the push mode. The worst cases occurred in waves as low as Hs 1.9m and as high as Hs 3.0m and Tp 8.3s when the tug was operating on the unshielded side of the LNGC.

Some of these concepts or parts thereof, particularly the fluid transfer arrangements, have been approved by classification societies in principle. Nonetheless, the oil and gas industry has always exhibited a certain amount of conservatism towards utilising these technologies and as Van de Valk and Watson (2005) pointed out in a recent study, stern to bow schemes are less attractive in view of the novel LNG transfer technologies.

OPTIONS FOR OFFSHORE DEVELOPMENT

As in the oil trade, export from FLNG terminals to visiting export tankers can be achieved in one of two ways, either in a tandem mooring or side by side arrangement. Until such time as a cryogenic subsea pipeline suitable for the low carriage temperatures of LNG (minus -163°C) is developed, loading from a Single Point Mooring (SPM) stationed close by is not an option.

In the same study it was concluded that side by side mooring of a LNGC to a weathervaning barge in a severe multi-directional wave climate is not feasible; as operational experience suggests it results in insufficient uptime. As MARIN stated following their pilot study prior to initiating the SAFE TUG JIP last year, and presented at OMAE in June, the requirements for the uptime of new offshore terminals for LNG are extremely high at between 95-99%. In the wave climates associated with the majority of proposed offshore locations, it is generally accepted that the current development of tug technologies and modes of operation do not permit these demanding levels of uptime with sufficient confidence.

LNG project developers and floating systems contractors, together with cargo custody and fluid transfer system specialists, have for several years been developing and presenting an array of options for tandem off-take for FLNG.

In some of our audience today may take exception to this assertion, but the fact remains that the mode of operation is unproven and until such time as developers are able to present what can be called "quantitative" evidence of performance to meet these requirements, such schemes will remain no more than a basis for design. However, for rather benign metocean conditions, Van de Valk and Watson conclude, the option is the preferred solution because it is based on the use of proven equipment and procedures.
Despite these stated limitations, the consensus of potential developers is that the technology would work, and the view of some developers is that the economics probably would work as well. As Onassis and Hurdle (2004) indicated in their recent paper, FLNG facilities are increasingly being seen as a viable way of retrieving LNG from remote locations. Certainly, had it not been for the sovereignty dispute surrounding the Greater Sunrise project off the coast of NW Australia we may well have been closer to FLNG being a reality than we are today.

Hurdles to Execution

Research into the behaviour of “tethered” tugs in severe wave climates has received little serious attention. Floating oil production systems have always relied on tandem mooring solutions to their custody transfer challenges in severe wave climates and dynamic positioning or taut moorings in place of conventional marine support and side by side berthing/loading. This has only required the services of an OSV/standby vessel to mitigate the effects of fish-tailing on occasion and has provided no incentive to study the subject further.

In meeting such demanding uptime requirements as those stated above, tug designers have had to embark on a reassessment of the nature of tug performance; in much the same way that escorting brought a new set of requirements, and a similar reassessment in predicting with a high degree of accuracy the actual performance achievable under a new set of parameters.

Nonetheless, there are a number of hurdles to making floating LNG a reality in more severe wave climates in addition to accurately defining the basic calm water behavioural characteristics of the tugs themselves.

Tug Design Optimisation

The motions of floating vessels in waves have exercised the minds of designers for many decades. Modern hydrodynamics has identified and proven several ways in which motion response of floating vessels can be significantly improved. Amongst them the addition of deep skegs; appropriately sited bilge keels; the judicious use of water line sponsons and flares together with, in the case of tugs, close attention to the optimisation of the towing point. Many modern tugs today apply such methods to improving not only when escorting at speed but as a means of reducing motions and accelerations in a seaway when operating in ship assist.

Opening the operability envelope in severe wave climates has also to take account of the possible interactions between different bodies; the FLNG unit, the LNGC and the tugs. In more benign environments these interactions present no significant obstacle to capability for most modern harbour tugs and in any event are well known, at least on an empirical level, but as the wave climate becomes more severe these interactions can dominate performance in certain modes of operation.

Response

There is also the related question of how this environment affects the tugs ability to respond to orders either from a purely mechanical performance based assessment as well as from a human perspective. What limits are there on the tug taking up a requested position and applying the appropriate thrust and direction in sufficient time and how does the master/pilots perception of “safe” alter or contribute to this ability in these more severe conditions? The effect of these continuously changing interactions on the human inputs to the system of the tug masters, the ships master and the pilot represents essential knowledge in developing a safe and effective operating methodology.

Performance

We must also ensure that sufficient data is available regarding performance degradation in various modes of operation and what limitations this places on safe operations – thruster-thruster interactions and thrusters-hull interactions. An understanding of what effect such a wave climate has on the performance and efficiency of various propulsion systems will be essential to establishing the base case specification for the support fleet.

Equipment

Developing an understanding of the dynamic forces at work in this system is essential to managing the towline forces and specifying the necessary technical performance characteristics of the towing equipment, towline materials as well as the towing and shipboard connection points. Recent research, prior to SAFETUG, had identified peak towline loads as high as 10 times the rated bollard pull of the tug under certain conditions. This is clearly unmanageable in the context of routine ship assist operations and against currently accepted towing winch safe working loads. Although applied to a different challenge, BA Griffin Associates Inc. developed a dynamic winch for escort operations, described in their paper presented at ITS 2004, that appears to have resolved many of the challenges of dealing with peak towline loads in a seaway. Opening the operability envelope further will have to build on work such as this and perhaps develop other novel developments borrowed from the offshore sector, such as those utilised on heave compensation systems.

Stability and Handling

There is then the issue of providing adequate stability for both optimising safety and performance. Optimising the hull design can ensure that there is adequate residual dynamic stability in all normal operating conditions and in all modes of operation. The effects of free water on deck are well known and modern escort class tugs are designed with freeboards sufficient to limit the ingress of water during indirect towing and thereby improve stability and handling. Plus crews need to be protected as they go about their day to day duties.

Crew Safety and Performance

Issues of crew performance, comfort and fatigue are subjects that have received much attention in the past but related principally to seagoing ships although in some cases has focused on smaller vessels. As the Buchner, Dierx and Waals paper noted, the NORDFORSK study identifies different types of work or operations at different locations onboard which impose different levels of motions and accelerations as limiting criteria. The results of the pilot study would suggest there is a considerable amount of improvement needed in opening the operability envelope for FLNG, as the limiting conditions were frequently exceeded during those trials – although it did stress that these results were clearly a function of the natural period of the tug and the application of roll reduction devices, which were not present in the tests. More chronic fatigue, of course, can be induced from motion sickness and its effects are well
Operational Considerations

In attempting to expand the operability envelope for offshore LNG operations we will be armed with new knowledge about all aspects of overall tug performance. It is almost inevitable that such new knowledge will challenge our preconceptions about what we might refer to as generally accepted operational methodologies given the new challenges that face the industry in this operational theatre.

The experience gained by tug masters during the test programmes for SAFETUG and importantly during subsequent full mission simulations, using the data gathered, will be invaluable in establishing the boundaries of operability, defining tug assist strategies and developing operating guidelines.

As in any operational context training, both general and project specific, will play a pivotal role in establishing a skilled pool of professionals, a guide to best practice and ensure that operations are always conducted within safe limits.

FORWARD LOOKING

SAFE TUG represents a significant step in Opening the Operability Envelope by defining what is currently possible with tug support for Offshore LNG. It will provide the foundation on which we will have the ability to build; in an area of critical importance to the future of the energy markets, given the growth in gas consumption world-wide, on which a great many of our businesses depend.

It will also inevitably challenge us to extend the boundaries. Challenging the boundaries of performance and possibility always focuses ones attention on the manner in which ones objective is achieved. With new knowledge comes new ideas and innovation. New ideas and innovation will remain the constant challenge for tug designers, equipment manufacturers and operators in opening the envelope to the possibility of monetising these vast reserves of gas offshore.

To use an oil analogy:

“We usually find oil in a new place with old ideas. Sometimes, we find oil in an old place with a new idea, but we seldom find much oil in an old place with an old idea. Several times in the past we have thought we were running out of oil, when actually we were running out of ideas.” – University of Tulsa Petroleum Geology Professor Parke Atherton Dickey, September 1956.

References

Source: Cedigaz – Hydrocarbons Reserves: Abundance or Scarcity?, OAPC-IFC Seminar, 28-30 June 2005


Robert Allan Ltd, New Technologies in Tugboat Design for the Oil and Gas Industry – Middle East Developments, SIGTTO Middle East Forum, 23 February 2005


Offshore LNG Production – How to Make it Happen, John A Sheffield, Business Briefing – LNG Review 2005


Barry Griffin, Ship Assist and Escort Winches for Dynamic Seas – The ARR Winch for Crowley Maritime tug Response, 18th International Tug and Salvage Convention, 26-30 April, 2004

NORDFORSK – Assessment of Ship Performance in a Seaway, Copenhagen, 1987


DISCUSSION – DAY TWO, PAPER No. 3

Mike Allen
You say, quite rightly, that there is going to be a need for quantifiable design criteria for operating in severe conditions. Where is the funding going to come from for this research? Who is going to do it?

Gary Dockerty
Well, I’ve been involved, certainly when I was in project development with Shell and subsequently with SigTow. It’s always been a subject of some discussion and some research, mostly on the mooring and the fluid transfer side of things. That funding has come from the oil majors and the contractors that supply that equipment. I’ve subject of ship assist has been one, as I mentioned, that has had very little meaningful attention until this point and the Safe Tug JIP funding, if I can pick that as an example, is coming from the stakeholders themselves. That’s the tug operators, the oil majors, which I made reference to the incorporation and commissioning of that. So I think we’ve all got a vested interest in moving that, given the time frame, it will become the primary energy source inevitably. So I think we’ve all got a vested interest. And the funding is coming from that as well as from other sourcesThere’s been no other EU funding proposals.