When bigger is better…

Prelude FLNG, the world’s biggest floating structure
Imagine the largest LNG carrier in the world…then multiply the size by a factor of five. This gives you an idea of just how big Prelude - the world’s first floating liquefied natural gas (FLNG) project - really is. At just under half a kilometre in length and 73 meters wide, Prelude will eventually contain 260,000 metric tons of steel – that’s more than was used in the original World Trade Centre in New York. With an expected life cycle of at least fifty years, a huge amount of stainless steels, including duplex grades, are used in the project. Stainless Steel World met Andrew Barnes of Shell Global Solutions and Anthony Pearson of SBM Offshore at the recent Duplex Seminar & Summit, where they presented this mammoth project. Andrew provided an overview of the project and Anthony talked about SBM Offshore’s contribution, as providers of the turret, and some of the materials challenges it is presenting.

By Joanne McIntyre & John Butterfield
If you stood the Prelude on end it would be around the same height as the Taipei 101 building, and would loom 50m higher than the Petronas towers in Kuala Lumpur. Yet with a lifespan of at least fifty years, Prelude is described by Shell Oil as an environmentally friendlier alternative to an onshore LNG refinery. After all, it can be redeployed to new fields and uses 80% less materials and has 95% less land and seabed disturbance than land-based refineries. Yet every year it will produce more LNG than Hong Kong uses annually.

Anthony Pearson, Materials Department Manager at SBM Offshore is closely involved with the project. “My role at SBM is to manage the Material Department, a team of engineers concerned with all aspects of materials engineering and corrosion protection for projects during the design, engineering and construction phases and, for SBM’s operational fleet of FPSO’s, also during production in the field,” explains Anthony. “Effectively we take care of the whole scope of materials related activities throughout the project life cycle. At SBM engineers are assigned on a project basis to provide the opportunity to participate at every step, so they work on a project from beginning to end. A major advantage of this approach is that if issues or problems arise, the engineers involved know the full history of the project. I still remain involved in the technical aspects of materials engineering myself as much as possible.”

In addition to providing leadership to the Material Department group, Anthony’s responsibilities include ensuring that adequate resources and the right technical expertise are assigned to the many tasks the group carries out.

**Why bigger is better**

It’s hard not to picture Prelude as a giant of the seas, but paradoxically it’s the miniaturisation that the design represents that makes the vessel economically feasible. The huge hull is still far smaller than an onshore refinery, and Shell Oil describes it as “more environmentally friendly” than an onshore plant. Given that it is located far out at sea, Prelude does not have the same environmental impact as onshore refineries with respect to land use, pipelines, and risks to local populations. FLNG is a revolutionary technology that will allow Shell to access offshore gas fields that would otherwise be too costly or difficult to develop; in this case in the Browse Basin, 475 km northeast of Broome, Australia. Cooled to -162° Celsius (-260°F), the natural gas shrinks to 1/600 of its volume when it is turned into LNG. Prelude will remain on location off Australia for 20-25 years to develop gas fields in the Browse Basin (see Table 1).

### Table 1. Key facts

<table>
<thead>
<tr>
<th>Location</th>
<th>Browse Basin, Australia</th>
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<tbody>
<tr>
<td>Depth</td>
<td>~250 metres</td>
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<tr>
<td>Category</td>
<td>Floating liquefied natural gas</td>
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</tbody>
</table>
Design process – more duplex being used

“SBM has an extensive R&D and Concept Department which is in charge of developing new products; it’s where the new ideas begin, the plans are drawn up and we assess feasibility,” continues Anthony. “When those ideas become more mature designs we start to look at them from a material’s perspective to make sure that the proposed materials have the correct characteristics to perform their intended function. We look at both the mechanical characteristics and corrosion protection aspects. Factors to consider are base material selection, protective coatings and cathodic protection to ensure that components maintain satisfactory performance throughout the full service life. It’s an interesting process.”

Duplex the alloy of choice

Anthony is seeing a general trend towards the use of duplex materials due to the increasingly harsh conditions in which SBM’s offshore facilities operate. “We use a lot of duplex not only because of its inherent corrosion resistance being suitable for a wide range of applications, but also because of its elevated mechanical properties in comparison to other similarly corrosion resistant alloys.” “As field conditions become harsher and the fluids become more aggressive, we need to select appropriate materials to ensure the most cost-effective solution to provide the required performance. Duplex stainless steels fulfil these selection criteria in many cases.”

For the Prelude FLNG many duplex components are coated with thermally sprayed aluminium coating – see box ‘Coated duplex’.

Coated duplex

While many people have the idea that duplex and super duplex are completely corrosion resistant, this is not the case. “On the Prelude FLNG project we are using a lot of thermally sprayed aluminium coating on duplex stainless steel,” explains Anthony. “This is now a Shell requirement and internally at SBM we are also examining the merits of this to provide additional protection against pitting corrosion and external chloride stress-corrosion cracking. The choice of thermally sprayed aluminium coating is driven by the clients’ experiences in the field. As duplex are not completely corrosion resistant applying this coating is a more economical step than moving to a more corrosion resistant alloy material.”

Pushing the manufacturing limits

Given the impressive size of the Prelude FLNG it’s no surprise that the sizes of some of the individual forged parts are truly enormous. For example the Gas Production Swivel Inner Part, forged in solid duplex, weighs 14500 kg and measures 2450mm outside diameter. The Gas Production Swivel Outer Part, also forged in solid duplex, weighs 17200 kg and measures 2990mm outside diameter. The concern is that during the solution heat treatment of these very thick items the interior cools down much more slowly than the exterior of the part, increasing the potential for the precipitation of detrimental phases. Methods the SBM team have developed to deal with this challenge include:

• Minimizing the heat treatment profile of parts by pre-machining to near nett shape prior to final solution annealing (including cutting of inlet/outlet penetrations prior to heat treatment);
• One of the challenges these large parts present is the extended time it takes to transfer them to the quenching bath, which according to the standard NORSOK M-650 should be achieved in less than 60 seconds. Transfer time from furnace...
to quench bath not considered too critical for large section forgings (>60s can be tolerated);

- Optimising the quenching process (including water temperature control, agitation, central water jet for ring shaped parts, etc.).

“As we develop items with larger dimensions it is apparent that the existing standards simply can’t be considered to be fully applicable,” continues Anthony. “When it comes to the qualification of materials we have to provide assurances that the materials we are producing and delivering are actually fit for purpose. This means that in terms of qualification work, we are not always compliant with some specified client requirements.”

The sheer size of Prelude FLNG means the project is approaching some of the manufacturing limits for the materials used. “There is a disconnection between the requirements that are specified by the clients which are essentially aimed at standard components, and the specialized items that are used parts of this project,” explains Anthony. “We had to quickly identify in the specifications where this could potentially be an issue and open a dialogue very early on with the client, Shell Oil. We have had extensive discussions to justifying the deviations we were requesting from specified requirements and ensure that these are supported by appropriate technical data.”

“With new projects like this there is cooperation required on both sides until you reach a technically acceptable compromise. This is one of the benefits of having the Material Department involved right from the start, reviewing the specifications and identifying possible difficulties and issues before they arise.”

Finding the right resources

A project this size demands a lot of specialized expertise and resources, as Anthony explains. “Finding the right people is very difficult in this industry. At SBM we have significantly strengthened our Material Department over the last three years and finding the right people has been challenging. This is a discipline where experience is really a key factor. We assign new team members to a whole spectrum of projects as they need exposure to as wide a field as possible to develop their skills and expertise. You can’t staff a department solely with University graduates; we need a mix of youth, enthusiasm and experience.”

Looking ahead for the FLNG industry it seems clear that larger vessels will become more common. “The trend is to go bigger, although practical limitations will prevail. Prelude is an enormous construction and facilities such as shipyards all have a limit which we have to work within.”