



Thermoplastic Composite Riser

Extending the Operational Envelope to Deeper Waters

Introduction

Most of the newest oil discoveries are found offshore – in ever deeper waters. Current technologies in Top Tensioned Risers (TTRs) and Steel Catenary Risers (SCRs) are approaching their technical limit. Some developments push these limits with current technology, increasing the cost to unprecedented levels.

Airborne proposes a Thermoplastic Composite Riser (TCR) as alternative to current solutions, including Free-Standing Hybrid Risers (FSHRs). The TCR will achieve a break-through performance improvement in terms of weight, top tension, fatigue, stiffness, strain and cost of installation. This white paper will show how current issues can be addressed effectively with the TCR technology.

Challenges

Top Tensioned Risers run straight from seabed to surface and use a tension all through the riser system to maintain stability. At increasing water depths, the steel cannot support its own weight, creating the need for buoyancy modules. In addition, as steel cannot handle much strain and is very stiff, the motion from the floater must be de-coupled from the riser through a heave compensation system.

With increasing depths, the weight and size of the riser increase as well as the weight and cost of the heave compensation system. This process quickly reaches its limitations.

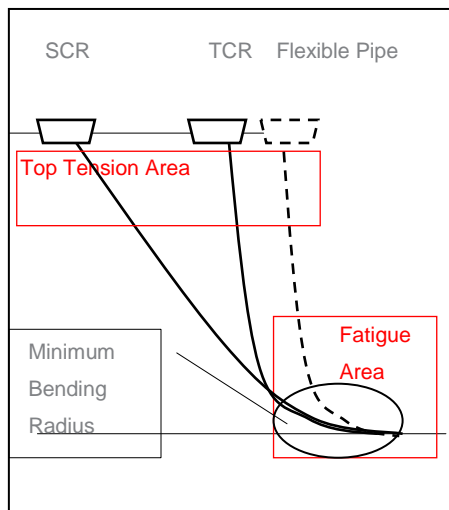
Steel Catenary Risers, installed in different configurations depending on local conditions, show top tensions for larger depths that cannot be supported by steel anymore. Expensive distributed buoyancy is applied in such way, that the top



High-Strength Low Weight Tubulars



Straightforward End-Fittings



TCR Small MBR and Low Weight

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tensions reduce while the SCR remains dynamically stable. Installation of a SCR itself is expensive with offshore fabrication of the SCR. The costs increase further by the increasing requirements for buoyancy.

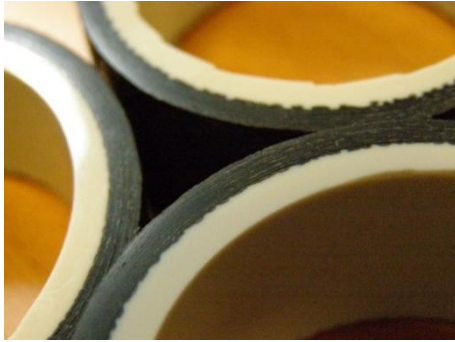
Solutions

Airborne proposes to use a Thermoplastic Composite Riser as alternative to TTRs and SCRs:

- The weight is much lower than steel, reducing top tensions in the risers and extending the operational envelope to larger water depths. Several analyses have shown submerged weight reductions of 75% compared to steel.
- The lower top tensions reduce floater loading. With top tensions amounting to 60% of total floater loading, significant weight reductions have huge impact on floater size and cost.
- The allowable strain is much higher than with steel, reducing or even avoiding the need for expensive heave compensation systems in TTRs.
- On SCRs, the Minimum Bending Radius (MBR) is much smaller than steel, which, combined with higher fatigue resistance, avoids issues at the touch down point.
- As the TCR is manufactured as a continuous string, installation cost is much lower than with SCRs due to avoidance of offshore fabrication.
- The stiffness of the TCR is a factor 10 lower than steel, allowing the TCR to be deployed in catenary configuration in shallow waters.
- The all-composite TCR is superior in fatigue resistance and impervious to corrosion.

Compared to flexibles, the TCR features the following benefits:

- The bonded reinforcement layers support all load cases, resulting in a fail-safe design.
- Due to the bonded nature of the TCR, friction is avoided and with that, wear-related damage.
- The end-fittings are simple and cost-effective due to the solid cross-section, avoiding any mooring of individual layers.



Perfect Bonding



Pilot Production Line



Bending Fatigue Rig

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- The TCR allows for a tailored pipe design, with for instance high collapse strength at the touch down point and high tensile strength in the top tension area.

Tubing and manufacturing concept

The technology developed by Airborne consists of melt-fusing fibre reinforced thermoplastic tapes onto a thermoplastic liner. In this process, a fully-bonded solid wall structure is created, covered by a coating of the same thermoplastic compound. The unique character of this technology offers specific benefits:

1. The liner is reinforced, which results in a collapse resistant pipe system.
2. The solid wall system enables simple and cost-effective end-fittings and connectors to be used.
3. The high allowable strain makes the pipes spoolable without fatigue and without cracks.
4. High ductility results in unsurpassed toughness, impact resistance and residual strength.
5. Minimized risk of liner buckling provides optimal gas decompression resistance.

Airborne's pilot production line has proven our capability to produce continuous spoolable pipe systems using Glass & Carbon fibres and PE, PP, PA & PVDF polymer materials to provide the optimal solution for each application.

Airborne is about to commence with a Joint Industry Programme for this development in conjunction with MCS and OTM Consulting. This JIP is sponsored by leading oil companies.

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