Publishable Summary

Oil and gas exploration is being carried out in ever deeper water, as more readily-exploitable reserves become depleted. And whilst previously uneconomical deep-water oilfields are now becoming financially viable, accessing them remains difficult due to the technical challenges associated with extreme operating conditions. Nevertheless, ultra deep-water reserves are highly attractive, accounting for 41% of new reserves discovered between 2005 and 2009: these reserves represent a market niche and the exploitable opportunity for CeraSphere.

The project has developed a novel, coated ceramic sphere that will be used to impart neutral buoyancy to components used in ultra-deep-water oil and gas exploration. This will be achieved through the development of new elastomeric resin-coated ceramic spheres that have greatly improved wall strength, as compared to the existing EPS sphere technology. Optimal sizing and spacing of the spheres will be determined by modelling activities involving buoyancy and packing efficiency. These new spheres – with enhanced compressive properties – will then be packed and cast within epoxy resin to produce the buoyancy unit – a syntactic foam containing macro-spheres.

When working in deep-water at depths of up to 5,000m the water pressure is above 500 atm. Components and systems for extracting oil and gas need to be neutrally buoyant, in order to maintain them in the desired position. Buoyancy modules for drill risers used in oil and gas exploration lines are currently made from syntactic foams using micro-spheres (up to ~2,000m) and macro-spheres (up to ~3,000m). Macro-spheres offer buoyancy advantages, but become increasingly unreliable at greater depths, owing to manufacturing inconsistencies. A typical deep-water buoyancy module will contain thousands of tightly packed spheres, and when a buoyancy module fails this can necessitate costly repairs (€100s of thousands plus considerable lost production costs) and lead to environmental harm.

Buoyancy units (Figure 1) are a relatively mature technology, but new products are still brought to the market on a regular basis especially as oil and gas exploration is moving into new territories which require greater exploration depths.

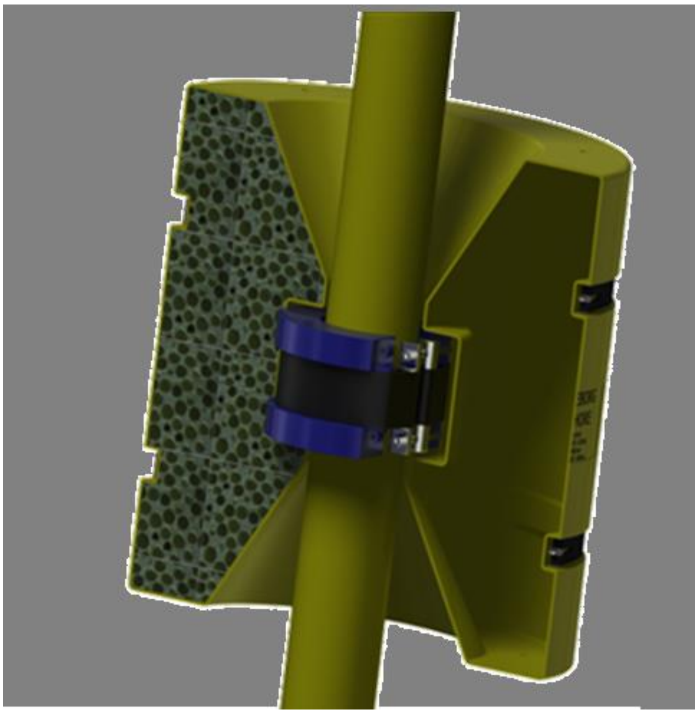

Figure 1: Schematic diagram of a buoyancy unit

In order to ensure that the SMEs' commercial needs were adequately addressed a state of the art review has been carried out reviewing the performance specifications for the buoyancy unit, review of appropriate ceramic materials and candidate binder systems.

Initially we reviewed the materials (ceramics and binders) for making the spheres and guided by Trelleborg we produced a specification document determining the sphere hydrostatic compressive pressure (HCP) requirements at different depths.

Ceramic materials have been developed for sintering at a range of different temperatures (1200 - 1600°C). Selected formulations were tested by Trelleborg and from the results formulations were chosen for going forward.

Sacrificial moulds made from different materials have been made using injection moulding and polymeric materials however none of these proved viable. A number of different pulp materials were tested and although they assisted the casting process none game the desired result for the CeraSphere. The consortium then went to the contingency material and produced spheres from plaster moulds. These were not sacrificial but allowed quality spheres to be produced.

A biaxial-rotational manufacturing machine was developed during the project that allowed multiple spheres to be manufactured at the same time. This machine can be up scaled post project to allow faster manufacturing rates.

Due to the requirements for producing the buoyancy units a coating was chosen. The consortium have decided that due to cost and increased production time in applying the coating this will only be used if a suitable buoyancy chamber filling technique that doesn't cause the spheres to shatter.

Mathematical modelling has been carried out to determine the optimum size(s) of the ceramic spheres to achieve the best packing density available. The modelling work has determined the stacking structure and the optimum balance between void density in the matrix (i.e. loading of spheres), compressive strength of the matrix, and buoyancy of the final system.

CeraSpheres covering the sintering range (1200 - 1600°C) have been produced (Figure 2) with the correct buoyancy and Trelleborg have converted these into buoyancy units which were tested.

Figure 2: Ceramic Sphere

The samples of buoyancy composite were placed in a pressure vessel which was then subsequently sealed. The pressure was increased to 3000psi at a rate of 1000psi per minute. Once pressure was achieved, the pressure was maintained for 1 hour during which time the pressure and applied volume were recorded in order that hydrostatic failures could be identified.

Samples tested were as follows:

- Clay ceramic sphere composite, 2 off
- Alumina high temperature sphere composite, 2 off
- Alumina low temperature sphere composite, 1 off

All samples exhibited resistance to the applied hydrostatic pressure for the duration of the test without any noted hydrostatic event. Visual inspection of the sample following testing gave no indication of hydrostatic collapse.

This project proved the proof of concept and is now ready to move to the exploitation stage.

To aid dissemination of the CeraSphere project a secure website has been created which gives the public information on the Project Goal, Partners, Project Objective and Press Releases. For further information please refer to www.cerasphere.com

A patent search has been carried out both before and during the project and it was confirmed that that CeraSphere was not infringing any IP. A Trademark: CeraSphere for Class 20 - Non-metallic buoys for use in the gas and oil industry, has been purchased.