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## Design Predictions and Measurements During Installation of Suction Anchors With and Without Water-Flow System to Help Installation Through Layered Soil Profiles

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### Abstract

A novel cylindrical FPSO was recently installed at the Shelley Field in the UK Sector of the North Sea. The FPSO is positioned using a system of 12 mooring lines, which are fixed to the seabed using suction anchors. The soil conditions at some anchor locations were initially considered difficult for installation of suction anchors because of the upper layer of dense to very dense sand overlying soft to stiff clay with inclusions and seams of silt and sand. Due to the soil conditions and other uncertainties related to the installation resistance, some anchors were equipped with a water-flow system along the lower edge of the internal bulkhead stiffener to reduce the resistance of the dense upper sand against this stiffener during penetration. This system was only used for locations where the dense upper sand was thickest.

The estimated resistance and corresponding required underpressure were calculated during the detailed geotechnical design phase; these were compared with measured values during installation of the Shelley Voyager FPSO suction anchors during June/July 2008. The measured and predicted values correlate well and demonstrate that the water-flow system performed as expected. The anchors without the water-flow system penetrated through the upper sand and reached target depth as predicted. More detailed back-calculations from the locations with the thicker upper sand demonstrate that installation to target depth would likely have failed without application of the water-flow system.

### Introduction

This article outlines the use of a water-flow system for suction anchors to aid installation at locations with dense sand over clay. The original design predictions are compared with the measured values during installation. The predictions given here have not been updated for the purpose of the paper, and as such are true 'Class A' predictions. The original design predictions were made using standard analytical models, i.e. there was no detailed theoretical evaluation of the potentially complex mechanisms involved with the use of a water-flow system. After installation, more detailed back-calculations were also performed, based upon a more advanced resistance model.

The article presents the key information required a more detailed evaluation of the observations, including anchor dimensions, soil profiles and measurements during installation. The article therefore serves as a reference for this type of system and may be used for future installation of suction anchors in a variety of soil conditions. It should be noted that the term 'suction' in this paper refers to a relative underpressure with respect to the ambient hydrostatic pressure.

### The Voyager FPSO Project

The Shelley field is located in Block 22/3 of the UK Sector of the North Sea, East of Aberdeen and North East of the Forties Field. Oilexo is the field operator. The field is developed with a novel circular Sevan 300 FPSO (Floating Production Storage and Offloading) platform. The Sevan 300 has a storage capacity of about 270 000 bbls of produced oil. The FPSO is permanently moored at the location and it is equipped with two offloading stations for dedicated shuttle tankers (with Bow Loading System). Table 1 presents general technical data for the Sevan Voyager.