

## MONITORING OF DRIVEN PILE INSTALLATION FOR WIND TURBINE BASES

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### SCOPE

UTEC designed, tested, installed and operated the systems for positioning a pre-piling template (PPT) on the seabed followed by monitoring the level, inclination and separation of the four 40m long and 2.5m diameter foundation piles driven through the template at seventy locations.

The monitoring had to guarantee pile separation to +/- 0.05m, pile verticality to +/- 0.5 deg and pile height to +/- 0.20m so that the pre-fabricated steel structures supporting the turbines would each fit on the piles.

The monitoring was also critical to ensure that piles were driven into the layered chalk and overlying glacial till in accordance with the pile design which had been optimised based on an earlier field pile testing campaign. UTEC integrated their positioning and monitoring workscope with fellow Acteon companies; LDD for template design and fabrication plus Menck for piling.

The PPT was deployed from the Boskalis vessel Giant 7 in 2016 to install the foundation piles for the seventy 5MW wind turbine generators of the Wikingen DWF 75km off the German coast in the Baltic Sea.

### SOLUTION

UTEC designed a spread of instrumentation to monitor pile installation to the required tolerances. The design was based on having multiple, independent and calibrated measurement systems that were tested to prove them resilient to the shock loading produced from the pile hammer during piling.

Each of the four piles was installed through tower assemblies on the template. Each tower had instrumented hydraulic rams to adjust and measure pile inclination relative to the tower. Pile inclination and separation was monitored during piling by combination of the ram measurements and multiple inclinometers mounted in each tower.

These data were combined with attitude measurements from a fibre-optic gyrocompass also used to define PTT heading and inclination. Pile height/driven depth was monitored by cameras in each tower recording images of a laser line on a depth scale attached to the pile. The pile depth measurements were referenced to the seabed using altimeters (echosounders) mounted on the template at known offsets from the cameras. Further monitoring of pile height was obtained from pressure sensors on the piling hammer and seabed which, with measurement of seawater temperature and density, were converted to water depths.

The large number of video and data lines from all the sensors required UTEC to design and build a subsea multiplexor for data

transmission to the installation vessel where UTEC specialist and bespoke software combined the various data into live graphic displays of the PTT and piles.

Monitoring of pile installation required the offsets between all sensors to be defined with dimensional control techniques during the quayside sensor installation. A full onshore trial of the pile adjustment and monitoring systems was also done prior to mobilisation onto Giant 7.

Comparing the data between the sets of sensors in each tower during piling enabled the measurements to be corrected for the bending of the steel structure connecting the towers caused by the loads exerted on the towers by the piles. UTEC would also perform periodic dimensional surveys of the PTT to detect any permanent deflection to the structure to be accounted for in subsequent pile installation.

### RESULT

UTEC provided €2m of specialised equipment, software and personnel to support the installation of seventy sets of piles – all to the accuracy needed for turbine installation.

The pile installation, of which the monitoring scope was part, was delivered by the Acteon companies UTEC, LDD and Menck working together and communicating effectively to the benefit of Acteon and the client.



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