



## Offshore Cable Systems

LICEngineering A/S provides planning, analysis, design and support during installation of cable systems such as inter cables and export cables. The installation studies are based on fully dynamic analysis and gives the client detailed knowledge of allowable sea-states for safe operations, hazard and risks and possible mitigation measures. Additionally we perform cable testing for offshore windfarm cables at our test facility in Esbjerg, Denmark

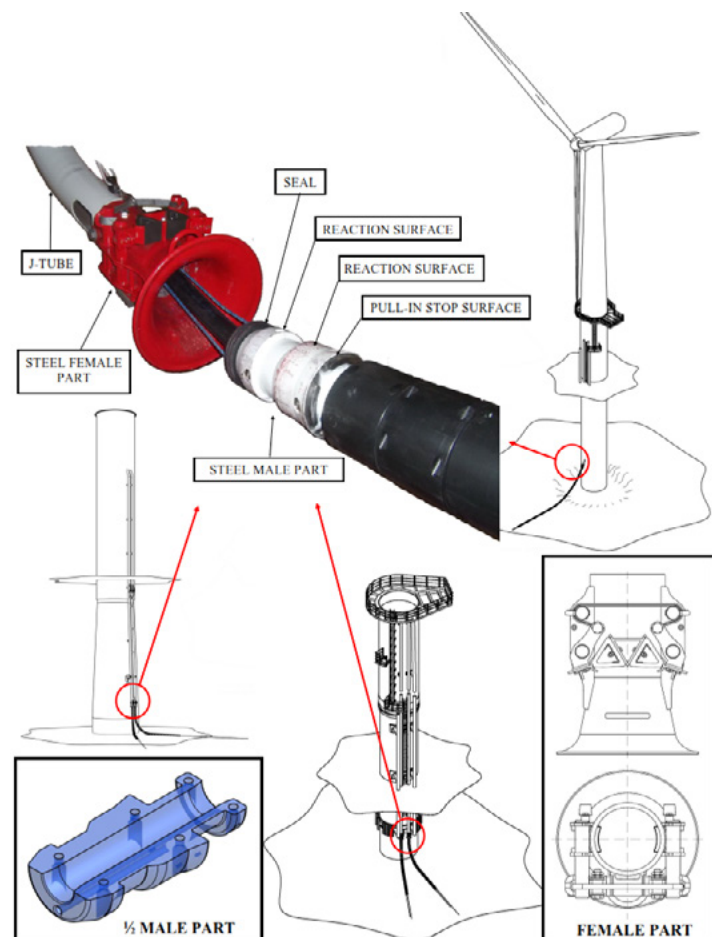
## Cable Protection Systems

LICEngineering has performed numerous design for cables and CCPS for offshore wind farms, including and dynamic cable studies in order to improve the protection layout of the system. The work has comprised testing of the existing CPS as well as and design of new steel/polymer/rubber components for re-instatement of centralizers which have slipped out of the cable pull-in bell mouth. The CPS design is based on the LIC Clawloks™ which is a combined Cable Connection & Protection System (CCPS). The LIC CCPS is a robust system which connects automatically to the J-tube during pull-in, seal the J-tube and can be released without diver intervention. The design is also based on experience from existing systems and improved in order to accommodate for today's requirements to safe operation and low maintenance cost.

The system includes a connection system, with a female-part which also function as the bellmouth. The cable ends in a male-part head, which connects mechanically into the female part by use of simple claws. The male part is combined with a modular cable protection system, which can be tailored to a required length between bellmouth and touch down point. The system provides automatic latching into the J-tube and diverless retraction of the cable and gives protection for the cable between the J-tube and the seabed – CCPS.



Inside of cable



LIC Clawloks

## Short CPS Solutions

The Cable protection System comprises of a modular system in half shelf as depicted to the right. Therefore, the CPS can be tailored to any requested length and also be installed/adjusted at the cable on the cable lay vessel during installation.

## LIC Clawloks

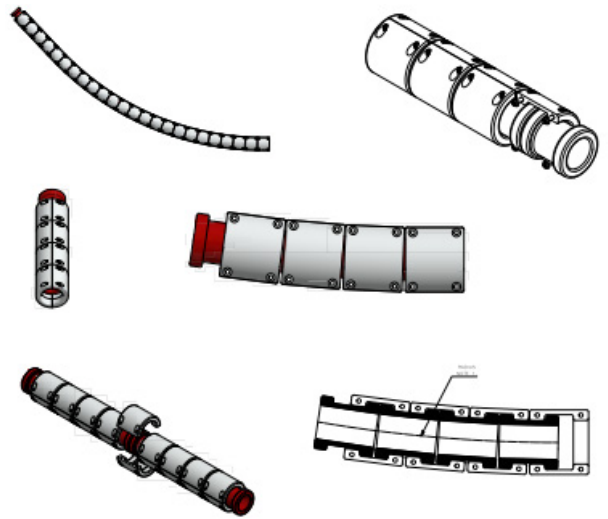
The Cable Connection and Protection System, CCPS, is based on the LIC Clawloks design. The system has been approved by testing in full scale for demonstration of the installation procedure, including required pull-in force, and diver de-connection procedure.

Currently 25 Clawloks systems has been installed on floating production units in the oil & gas industry since 2009 connecting cables, risers and flexibles to FPSO's. All systems are still in operation. The Clawloks CCPS has a number of benefits compared to the common systems used for offshore wind farm projects as of today:

- High strength / robust, ensure that the system lifetime of 25 years +
- Automatic latching into J-tube during pull in, ensuring cable remains in position.
- Sealing of the J-tube, ensuring no water replacement in the J-tube/Monopile.
- Diverless release system, comprising of either simple wire or ROV operated bolt
- Flexible protection system, allowing for adjustment of length during installation.

For the larger size Clawloks system for offshore oil & gas, LIC has developed the system from semiautomatic latching system and ROV hydraulic disconnection into a full automatic latching and retractable system. For these system spacers centralizing the cables in the J-tubes has been seen as an advantage for the wear and tear of the cables in the zone near the bell-mouth.

Recently, one of our systems has been retracted and inspected in Australia, where the centralizers were not in place from the beginning, which resulted in damage to the umbilical/cable after ~10 year in operation and the cable had to be replaced.



The CPS can be tailored to any requested length



Deployment off Turret with Clawloks Connectors



Close up photo of Clawloks Connectors



## Cable Testing

Testing includes both array cables and export cables and is typically carried out in order to establish various structural properties:

- Bending stiffness
- Axial stiffness
- Rotation/torsional properties
- Eigenfrequency for free hanging cable
- Structural damping for free hanging cable
- Armour layout and mechanical properties for failed cable

The test results are typically in used combination with advanced structural and hydrodynamic analyses carried out by our engineers. This includes determination of the dynamic behavior for the cable from exit of bellmouth to touch down on sea bed.

It may also include general performance of cable system, CPS protection arrangement, pull-in scenarios, installation of export cable over seabed rollers as well as possible failure modes and limitations for pull-in.

Furthermore test results have been used in combination with vibration analysis in order to investigate the dynamic behavior of free hanging cables inside the monopile foundations

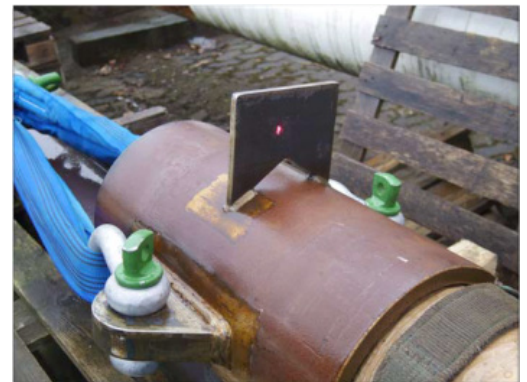
## Our Test Facility

Testing services are carried out using our yard facilities in Esbjerg and our 12 m long horizontal test rig assembly as well as vertical support structures and various work bench set-ups.

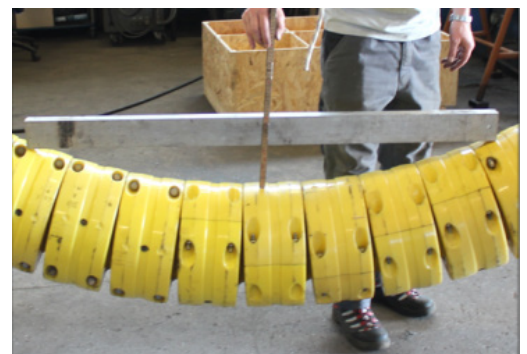
The test rigs have capability to perform extreme ULS load testing and fatigue FLS testing of cables with low cycle alternating transverse load and with cable in specified tension.



Dynamometer for logging of axial pull force



Laser pointing measuring device used for logging of cable twisting angle during axial pulling



Bend radius test for cable protection system (CPS)



Typical Array Cables

## Project References - Offshore Cable Systems

- 2018: Hornsea 1 Offshore Wind Farm - Preparing, analyzing and selecting installation contractors
- 2015: Walney Offshore Wind Farm Extension - Export Cable beach pull-in analysis in OrcaFlex
- 2015: Walney Offshore Wind Farm Extension - Export Cable free span analysis in OrcaFlex
- 2015: GodeWind Offshore Windfarm - Detailed Cable analysis of free hanging array cables inside and outside monopile. Assessment of fatigue and ultimate design life applying OrcaFlex
- 2014: London Array Offshore Windfarm - Re-analysis of the cable tie-in. Test of cables for overall strength and stiffness. Design and fabrication of retro-fit system for support of existing cable protection system
- 2013: West of Duddon Sands Offshore Windfarm - Detailed Cable pull-in analysis and installation procedure. Included workshop testing of cable strength and stiffness parameters
- 2011: West of Duddon Sands Offshore Wind Farm - Analysis of movements and fatigue damage of hanging cables
- 2009: Walney Offshore Windfarm - Development of alternative tie-in system of cables



Walney Offshore Windfarm



Offshore Cables



Cable Illustration

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