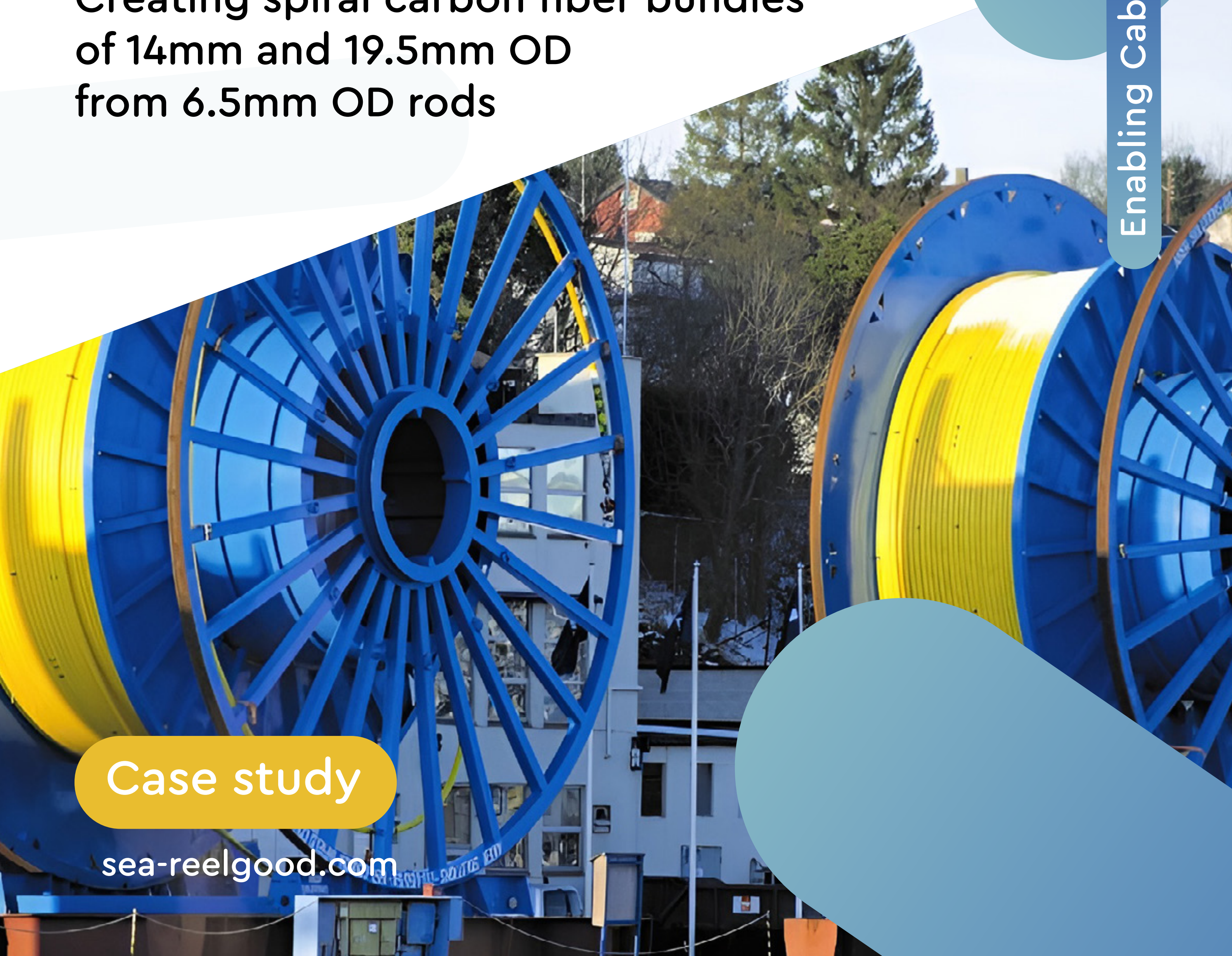
SEA
Reel Good

Rods & Wires

TotalEnergies GirRI Umbilical Project

Creating spiral carbon fiber bundles of 14mm and 19.5mm OD from 6.5mm OD rods

Enabling Cabling



Case study

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Customer	Location	Delivery schedule	Total quantity
Aker Solutions/ TotalEnergies	Angola, Offshore	Q4/2013-Q1 2014	130,000m onto 30 reels

summary

Why use carbon fiber in umbilical design?

Aker Solutions are pioneers in the development of carbon fiber rods for ultra-deepwater umbilical strengthening applications, first used in the Independence project in the Gulf of Mexico in 2005.

Carbon fiber rods were developed as umbilical strength elements for deep and ultra-deepwater applications. It was already known that if umbilicals were made using steel tubes for ultra-deepwater installations then the vertical weight of these steel umbilicals would cause them to stretch during deployment and electrical cables within the umbilical could become elongated and be damaged leading to failure. Carbon fiber has a density of only 1.6 compared to 7.8 of steel so provides a significant weight saving over steel. Carbon fiber also critically has significantly greater axial stress resistance (it prevents an umbilical from stretching). So, the key advantages of carbon fiber rods are a) to prevent deep-water umbilicals from stretching during instillation and b) to provide a much lighter umbilical design for ultra-deepwater installations, and c) to help prevent the umbilical from being crushed when clamped by the installation vessel.

In the early days of the technological development of ultra-deepwater carbon fiber rod applications in umbilicals in the Gulf of Mexico, they were used in single straight rods as well as bundles of straight rods.

After these early installations, the Aker Solutions umbilical design team in Fornebu, Oslo realized that a spiral bundle of carbon fiber rods (CFR) would have significantly more axial stress resistance compared to single carbon fiber rods, and for a negligent increase in weight, for example a 7× 6.5mm spiral bundle of CFR has 7× more axial stress resistance than a single coil of CFR.

objective

Turn your dreams into reality

Technip won the GirRI Phase 2 offshore Angola EPCI contact from TotalEnergi to supply 21km of umbilicals comprising of two dynamic power and control umbilicals (P70, P80) and one dynamic power cable (IPC).

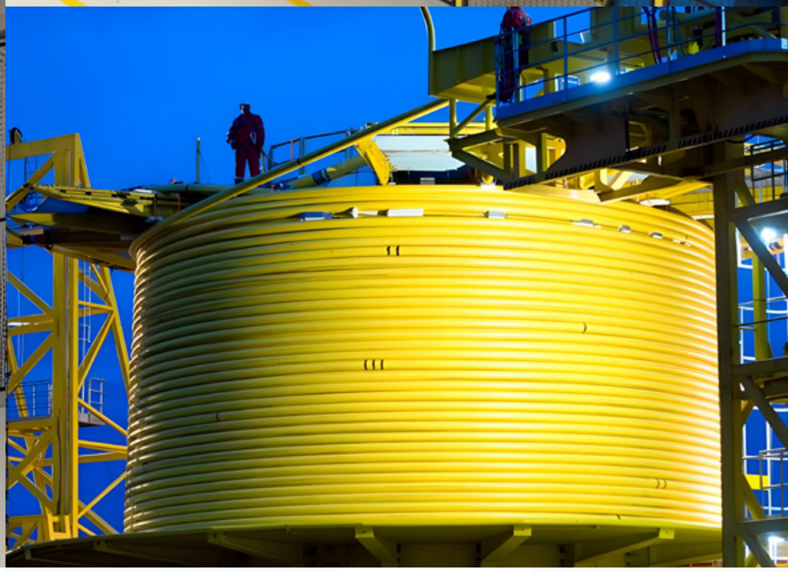
In 2012 Aker Solutions was awarded the umbilical contract from Technip and their tender called for the production of the first ever spiral bundled CFR for the Girossol Block 17 oilfield, located 210km west of the Angolan capital, Luanda in 1300m water depth.

Aker Solutions knew that SEA produced bespoke machines and automated production lines so they approached SEA with a unique question; could SEA design, build, and operate a unique lay-up and bundling machine to produce long lengths of spiral bundled CFR of different outside diameters (OD)? Aker Solutions required the following products to be produced to meet the requirements of the three umbilical designs:

<u>Dynamic power and control umbilical (P70)</u>
6× 7-rod 19.5mm OD spiral bundles
3x 3-rod 14mm OD spiral bundles

<u>Dynamic power and control umbilical (P80)</u>
7× 7-rod 19.5mm OD spiral bundles for the dynamic umbilical
1× 7-rod 19.5mm OD for the static portion
3× 7-rod 19.5mm OD for the termination

<u>Dynamic power cable (IPC)</u>
2x 3-rod 14mm OD spiral bundles
12x 1-rod 6.5mm OD single strands



solution

SEA sets sail on a unique voyage

In 2012 the SEA design and engineering department began the design work in close collaboration with Aker Solutions engineers to design a unique machine capable of bundling single strands of 6.5mm OD into spiral CFR bundles of 3 strand 14mm OD or 7 strand 19.5mm OD.

After design was complete, it was clear that numerous components and machine equipment would have to be custom build by expert machinists then assembled and tested in the SEA spooling base prior to testing.

Another problem to be solved was how to join single strands of CFR together in order to spool the required lengths onto the final production reels? A special epoxy film adhesive tape was sourced from the USA designed to bond the single CFR together. This tape had to be kept specially chilled to at least -18 °C prior to application around the CFR joins. During trial production tests CFR join test samples were cut out and sent to Epsilon Composites in France for tensile testing.

The prototype production line was made up of five distinct mechanical stages plus a separate stage to bond single rods together with epoxy tape*:

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Pay-offs	Seven pay-offs controlled using disc brakes were built to fit wooden reels containing single carbon 6.5mm fiber rods supplier by Epsilon
Lay plate	Composites are pulled through a matrix plate closer. Two types of spiral bundles can be produced, 3-rod OD of 14mm and 7-rod OD of 19.5mm
CFR bonding	Individual CFR joined with chilled epoxy tape*
Taping head	The CFR bundle is bound with self-sticking tape to help sustain a proper lay length. Paper, plastic, or PVC tape can be used
Rotating caterpillar	Designed for pulling the bundle from the pay-offs with a max. pull strength of 20,000N
Take-up	The taped CFR bundle is then coiled on to the inter-operational reel
Rewinding line	A rewinding line was installed to spool the CFR bundle back onto Aker Solutions standard 2900mm cable reels for use in their umbilical HLM

The production line was operated from a central control cabinet using software designed by SEA engineers. The entire CFR machine was enclosed in a safety cage and operation could only begin when the cage door was closed so that the operator could activate the external control panel.

After a full FAT by the client in 2013 and slight additional modifications to the production line, the CFR bundling machine was ready for the first production run.

results

Strength, Efficiency, Cost Savings

The tensile test results from France of the epoxy CFR joined samples showed that as expected the joined single CFR had excellent axial stress characteristics and only failed at 625-689 MPa for an extremely high applied force of 22 kN. The spiral CFR bundles had far superior axial stress to single CFR estimated at >150kN which is more than the force from a jet fighter engine.

The epoxy bonding of the 6.5mm OD rods was extremely successful meaning that long lengths of spiral bundles of CFR could be produced thus greatly reducing the numbers of joins that the client had to make in Moss during the production of the umbilical thus saving them time and money.

During FAT, it was found that the operation of the CFR bundling machine had to be fine-tuned so that it operated with perfect synchronicity to produce bundled spiral CFR with the optimum tensile strength as required in the ITP. This stage involved fine-tuning the RMP of all rotating parts, adjusting the linear speed, the pull force, and tension, etc. Once the machine was fine-tuned production operations began. The length of spiral CFR bundles measured by capstan and spooled onto standard sized Aker Solutions 2900mm flange production reels was just over 4300m per reel. The maximum spooled length per reel was over three times the expected installation water depth therefore more than meeting the client's requirements.

Production reels loaded with spiral bundled CFR were transported to the Aker Solutions umbilical production center in Moss, Norway using SEA trucks on a regular basis. Regular delivery ensured that Aker Solutions could prepare ahead of time for the closure of the high value GirRI umbilical.

This combined approach guaranteed the delivery of a state-of-the-art product on schedule and within budget, bolstering client satisfaction and helping them maintain a competitive edge at the cutting edge of the umbilical market.

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ISO:
9001:2015, 14001:2015, 45001:2018, 17020:2012, 17025:2017, 3842-2:2005