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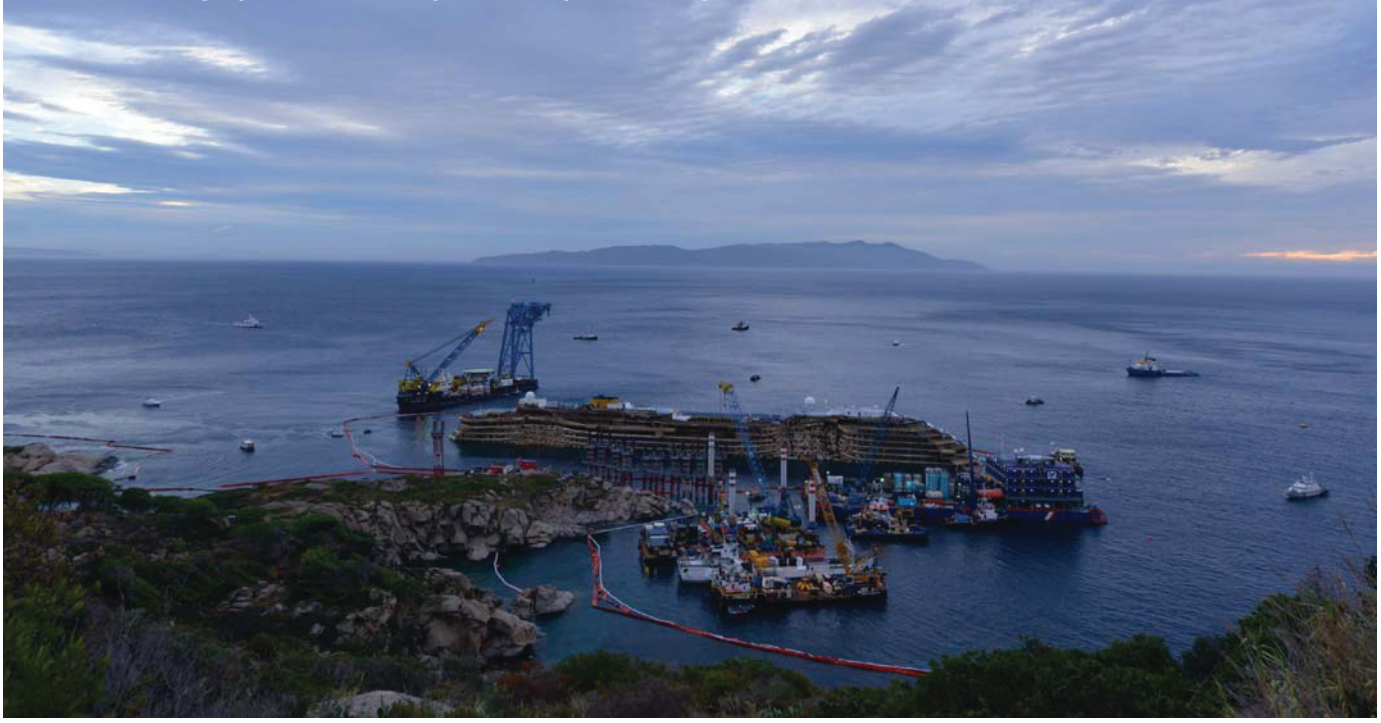
World's biggest salvage job is all tied up

Righting the cruise ship *Costa Concordia* is the biggest single salvage operation ever undertaken. The use of high-performance ropes in the parbuckling exercise was crucial to its success.



The largest and most complex maritime salvage operation ever carried out is expected to be completed this summer. The *Costa Concordia* parbuckling operation on the rocks of the Italian island of Giglio has been a success in many ways – not least for the objective of retrieving in one piece such a massive vessel (117,000 tons) with minimal damage to the delicate marine environment on which it foundered.

High performance ropes played a key role in the operation. Dutch manufacturer DSM Dyneema has been supplying HMPE (high modulus polyethylene) fibre, branded as Dyneema®, for ropes used in tug and salvage operations for almost 15 years. Ropes made with Dyneema have been used around the world to haul to safety everything from stricken ships stranded in shallow waters to hurricane-damaged oil platforms. But the ***Costa Concordia*** project is probably the company's most critical – and certainly its most high-profile – salvage project to date.

DSM Dyneema's strategy is to enable large and complex jobs to be carried out with increased safety and reliability, according to the company's Global Marketing manager, Kedar Sule. The ***Costa Concordia*** salvage operation is the ultimate example of this strategy working in practice.

"This is the biggest salvage operation carried out by anybody, anywhere," said Sule. "Never before has a ship of this size been salvaged in one piece. Normally wrecks are cut up and the pieces are then removed, but that was not an option in this case due to the location and its environmental sensitivity."

Steel wire rope remains the most commonly used product in salvage operations, followed by polyester rope. HMPE accounts for a small portion of the market, but its importance in environmentally-critical operations is being increasingly recognised. For the ***Costa Concordia*** salvage operation, the US-Italian joint venture between Titan Salvage and Micoperi ruled out the use of steel because of the high risk of damage it would cause to the sea floor, and to reduce the total weight of the parbuckling system.

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Titan-Micoperi realised early on that any ropes required for the creation of the holdback system, to hold the wreck in place and then help bring it upright, would rub along the sea floor. As is well known, ***Costa Concordia*** went aground in an area of great natural beauty where the underwater ecosystem is very precious. So it was imperative that any further damage to the ecosystem, beyond that caused by the ship itself running aground, be kept to a minimum.

For this reason, the decision was made to go for a rope system that is not only extremely strong, but also very light and easy to handle. As Dyneema has neutral buoyancy in water, the ropes can be easily pulled along by divers. Nick Sloane, salvage master for the project, estimates that installation of the ropes, including pulling into position and connections at each end, took about two weeks less than if steel ropes had been used.

▲ **Costa Concordia** *being refloated off the Italian island of Giglio.* *Photo: The Parbuckling Project.*

Although the ropes made with Dyneema did not drag along the seabed as steel ropes would have done, they were still in constant contact along much of their length with the hull of the ship. This meant that they needed surface protection – which is where Norwegian rope maker Offshore & Trawl Supply (OTS) comes into the picture. OTS-manufactured Dextron® 12 Plus ropes with patented protective jackets were chosen.

"With this solution, the rope cores are kept safer, as is the local ecosystem," said Sule. Also, the covers for the ***Costa Concordia*** project contain a reflective additive so they can easily be seen by divers working with torches in the dark.

The ***Costa Concordia*** operation has provided OTS with its largest single order and most high-profile salvage project ever. The company is increasingly being seen as the 'go to' choice for tug ropes, not least because of its high-performance protective jackets. For the ***Costa Concordia*** project, core and jacket are made in two different grades of Dyneema, each ideal for the specific application.

Vebjørn Løviknes, Sales and Marketing

manager at OTS, said: "The OTS protective jacket is probably the best synthetic protective cover for HMPE ropes in the market today."

In all, there are 22 Dextron 12 Plus ropes holding ***Costa Concordia***: two running from each of the 11 towers mounted on the sea floor along the starboard (shore side) side of the ship and connecting to chains that run under the hull and which are attached to the far (port) side. All the ropes have the same diameter, but each has a different length, of between 40 and 55m.

"Most of the work for DSM Dyneema was in the run-up to the production of the ropes," said Sule. "None of us had been involved before in an operation of this scale, and we only had one chance to get it right. But we have substantial technical expertise to back up our product, and we made it all available to OTS and to Titan-Micoperi.

"With this support, OTS was able to determine the construction, length and size of ropes needed to withstand the massive forces that would come into play during the holding and parbuckling operations. OTS was able to manufacture exact lengths of the ropes with great precision."

This may sound relatively simple. It is not. The mechanism in each tower for pulling the ropes during the parbuckling operation does not involve winding the ropes around a mandrel, but rather a long hydraulic cylinder exerting a pull in a single stroke. This means there was no room for any slack in the ropes to be taken up.

In addition, since the ropes were to be loaded for a prolonged period of time, creep had to be considered. Among the various types of HMPE fibre on the market today, Dyneema has been demonstrated to creep the least, and by a significant factor.

Creep is a phenomenon that occurs very slowly, but in the ***Costa Concordia*** salvage operation creep was going to be measurable over the several months that the ropes were holding the ship in place, and so it needed to be calculated in advance.

Even though creep is a well-known phenomenon, it is difficult to predict, since it depends on multiple parameters. However, DSM Dyneema has developed a sophisticated model that can accurately predict this irreversible elongation over the period of the salvage operation. The company is unique among HMPE fibre suppliers in being able to offer this type of support.

Marc Eijssen, senior application manager, Offshore and Industrial, at DSM Dyneema, said the company carried out a series of creep evaluations using its in-house model to predict creep under a variety of load and temperature scenarios. Based on these models, Titan-Micoperi and OTS were able to calculate the exact length needed for each rope. The model proved accurate, and the parbuckling operation went exactly according to plan.

"We are used to dealing with major projects, even if nothing compares to the scale of this particular operation," said Eijssen. "We have a lot of experience in marine applications ... but each case has its own specific requirements. We rely on our years of experience and technical expertise and strong partnerships to provide the right solution in each specific case.

"OTS was required to produce ropes with a breaking load of 1,100 tonnes," Eijssen said. "When the parbuckling operation was carried out in September, the vessel had been stuck on the rocks for 20 months, during which time its structure could have seriously deteriorated. We couldn't have it breaking up during the parbuckling operation, so each line had to fully contribute to avoid any chance of other lines being overloaded."

▲ *Norway's OTS produced Dyneema fibre ropes encased in a special protective jacket to minimise damage to the fragile marine environment around the wreck.* Photo: OTS.

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Marc Eijssen, senior application manager, Offshore & Industrial, DSM Dyneema.

Safeguarding the sub-sea environment was crucial to the total salvage operation. Eijssen explained: "Titan-Micoperi had originally considered constructing the holdback system using steel rope, despite its weight and handling disadvantages, and when its people saw early concepts from OTS based on Dyneema, they weren't convinced that a Dyneema solution would work.

"But following discussions with OTS at a salvage conference, they became convinced that ropes with a patented protective cover to protect the load-bearing core were the way to go." At this point, OTS informed Nick Sloane that DSM Dyneema were ready and willing to provide full support for the project.

Sloane has in fact worked with ropes made with Dyneema for more than ten years. "I personally find it an ideal component for salvage intervention," he said. On the specifics of this project, he explained: "The lines with Dyneema were under the 'shadow' of the ***Costa Concordia*** – as she lay on her starboard side. The sea-bed slope and uneven terrain meant we required something light, that would not snag on the sea-bed and that could be installed by a diver intervention to the turn of the ***Concordia*** bilge.

"We pre-loaded the ropes to 500 tonnes each in a complete system test. On the actual day of the parbuckling, the forces required to hold the keel of the ship in position were limited to around 170 to 200 tonnes, to allow for slight shock-loads to be absorbed by the system through the operation."

Now the parbuckling phase has been completed, the ropes have been kept attached to the wreck to hold it in position while sponsons are attached to the starboard side before it is refloated and removed from Giglio.

"We have a live monitoring of the loads in play on each hold-back component," Sloane said. "We 'swim' the hold-back system with an ROV every 10 days to inspect the systems – but to date the loads have remained reasonably static and the system continues to work.

"The choice of the ropes with Dyneema, along with the OTS abrasive-resistant outer protection coat, has resulted in a system that met our needs exactly on a very vital part of the parbuckling operation. The performance allowed us to carry out the operation without having to worry about a failure of the holdback system, and focus on the offshore side of the parbuckling components, which required continual monitoring and adjustments."

During the refloat operation, Titan-Micoperi will be relying on Dextron 12 Plus ropes in the mooring system to stabilise and control ***Costa Concordi***a.

At the time of writing, ***Costa Concordia*** was in the process of being refloated in readiness for taking away to a breakers' yard.