MODEC, a leading contractor in FPSO vessels, faced a challenge. The company was converting a vessel into an FPSO (floating production, storage and offloading) and as part of this wanted to equip the FPSO Cidade de Santos MV20, with a new mooring chain tensioning system.

**Wanted: two winch systems to pull in mooring lines**

The idea was to use two winches, fore and aft, to pull and tension 12 mooring lines each. This design would replace the usual chain jack at each mooring cluster. By doing this, the company could cut by a factor of four the time needed to pull in the chains. This in turn would reduce the time required to install the FPSO and so make it possible to accommodate short weather windows.

The FPSO Cidade de Santos MV20 is deployed in the Brazilian Urugua field and receives gas from the Tambau field, also in the Santos Basin. The processed natural gas is sent to the Mexilhão field, 170 kilometers from Urugua.
Needed: very strong rope which can bear small bending diameter
There were several reasons for choosing this design. It would be easier to route the rope and pull through the underwater fairlead, which had a very limited bending radius. The mooring winch could be made smaller, so claiming less deck space. And one winch could do the whole pull-in.

Above: MODEC wanted a centralized mooring winch fore and aft to pull and tension 24 mooring lines. These would replace the usual configuration of a chain jack at each mooring cluster. The FPSO Cidade de Santos MV20 uses a Spread Mooring System.

Right: The PH 350T/230T mooring winch used by the Cidade de Santos MV20 under tension. The high-strength Samson 120 mm Quantum™ 12 rope made with Dyneema® is lightweight, and its patented Samson DPX™ fiber technology provides superior abrasion and cut resistance, but with a higher coefficient of friction than other high modulus polyethylene ropes.

Needed: smaller bending diameter
Willie Ng, sales manager of PH Hydraulics & Engineering, one of Asia’s leading manufacturers of FPSO deck equipment and a long-time supplier to MODEC, calculated that with a pull force of 350mT, the FPSO Cidade de Santos MV20 would need a wire rope with a diameter of approximately 96mm, and a minimum break load of 796mT. With a minimum D/d ratio of 18 for low rotation wire rope, the required bending diameter would be 1728mm. However the diameter of the FPSO Cidade de Santos MV20’s underwater fairlead was only 1500mm.

The only solution: pull-in rope made with Dyneema®
PH had a solution, though. What MODEC needed was a pull-in rope that would be as strong as a steel wire rope, but with a bending diameter of under 1500mm, so it could be used with the existing underwater fairlead. There was only one answer: a synthetic rope made with Dyneema®. These are lighter and stronger than their steel wire rope equivalents and – crucially, for MODEC and the FPSO Cidade de Santos MV20 project – they can endure a much lower bending radius than the equivalent steel wire rope.
The order went to Gaylin, which supplied PH and MODEC with a Samson 120 mm Quantum™ 12 rope made with DPX™ fiber technology, this has an MBL of 887 mT and shows much lower strength-loss when bent than a comparable steel wire rope under the same conditions.

The FPSO Cidade de Santos MV20’s Samson 120mm Quantum™ 12 rope has an MBL of 887mT and shows much lower strength-loss when bent than a comparable steel wire rope. It also passes winch rollers easily and is seven times lighter than its steel wire rope equivalent.

All the specifications met – and more
As well as meeting the Fairlead/bending diameter criteria, the rope also met all the other specifications. It took up less deck space, one winch could do the job at each end, and the rope was much easier to handle and position on the winch’s rollers. It was one-seventh of the weight of a similar-strength steel wire rope.

In addition, the braided rope is intrinsically torque neutral, so it will not induce any twist in the mooring chains. This additional effect is highly appreciated by the installation companies. All boxes checked.

Left: The FPSO Cidade de Santos MV20’s 114mm mooring chain is held under tension by the Samson 120mm Quantum™ 12 rope, made with Dyneema®.

Right: The Samson 120mm Quantum™ 12 rope, made with Dyneema®, is slightly abraded after completion of two-thirds of the on-site tensioning operation. This generally doesn’t reduce the strength of the rope, and the surface fluffing it has developed will actually protect the rope from further abrasion.
Meet FPSO Cidade de Santos MV20

- **History:** built 1973, converted in 2008-9, first oil 2010
- **Place of operation:** Urugua and Tambau fields, Brazil
- **Client:** Petrobras
- **What 1:** Collects and processes natural gas from the Tambau field
- **What 2:** Sends processed gas to the Mexilhão field, 170 kilometers from Urugua
- **Processing capacity:** gas – 350 million cubic feet per day of gas; oil – 35,000 barrels per day
- **Storage capacity:** approximately 700,000 barrels
- **Did you know:** first FPSO to process more gas than oil
- **Water depth:** 1,300 meters
- **Mooring Type:** SOFEC spread mooring

Why Fiber Outperforms Steel

Tensioning mooring chains with steel wire rope raises a number of issues:

- Steel wire rope is too rigid to handle and position easily on rollers when changing the line pass. Soft ropes like those with Dyneema® are easy to guide to every area needed.

- With steel wire rope the anchor chain installation must be done in such a way that there is zero or near-zero twist induced in the chain. Samson Quantum™ 12-stand rope with Dyneema® is torque free.

- In the case of the Cidade de Santos MV20, the minimum bending diameter for low rotation wire rope under full workload (350t) is 18 times the diameter of the wire rope. The size of the sheave and Fairlead on rope travel pass is too small to accommodate a 96mm wire rope.

- Going through the sheave and Fairlead, the socket/bending tensioner at the wire rope termination point will suffer greater bending, so reducing the safety factor and increasing the risk mooring chain will drop to the seabed.

Withstanding the Strain

- **Samson 120mm Quantum™ 12 rope, MBL 887mT and 70 meters long**
- **Made with Dyneema®**
- **Includes Samson’s patented DPX™ technology**
- **Hybrid PET/Dyneema® at rope strand surface**
- **Greater friction helps hold rope in place and increase abrasion resistance**

Project Partners

- **MODEC** – FPSO operator
- **SOFEC** – in charge of mooring analysis
- **PH Hydraulics** – provided winch + rope made of Dyneema®
- **Samson Rope** – maker of Quantum™ 12 rope made with DPX™ fiber technology
- **Gaylin** – Samson distributor in Southeast Asia
- **DSM Dyneema** – manufacturer of UHMwPE Dyneema® fiber