

ConocoPhillips FPSO NanHai KaiTuo secured by back-up lines with Dyneema®

Installation of back-up lines with Dyneema®

Back-up lines made with Dyneema® can be used as a back-up scenario in the event of steel wire rope (SWR) or chain breaks in mooring legs of rig's, MODU's, BTM's and the alike. In case the SWR is already damaged, back-up lines with Dyneema® can be installed as a safety feature until regular maintenance takes place.



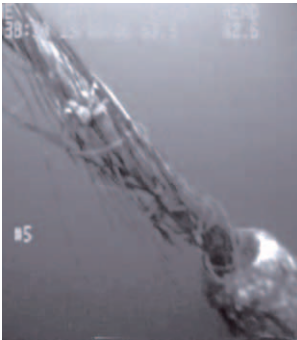
Damaged mooring legs of the Chinese FPSO NanHai KaiTuo

Xijiang Oil Field is located at the mouth of Pearl River about 130km from Hong Kong in the South China Sea. It is a large oil field which has been developed by Conoco Phillips and CNOOC. Oil production started at the end of 1994.

FPSO (Floating Production, Storage and Offloading unit) NanHai KaiTuo had been in the water for 14 years. In 2006 during a ROV (Remotely Operated Vehicle) inspection of the mooring legs, broken wires were discovered on two of the SWR mooring legs of its Buoyant Turret Mooring (BTM) system.

As part of SBM After Sales Services activities, SBM Services were requested by ConocoPhillips to design and supply a back-up system consisting of a special connector to fit a positively buoyant back-up line made of Dyneema®. Installation of this back-up system was required in case of a SWR failure in one of the damaged composite anchor legs.

The damaged anchoring system of the NanHai KaiTuo is part of a disconnectable BTM designed by SBM in 1993. The BTM consists of a subsea mooring buoy connected to an internal turret below the forepeak of the FPSO. The buoy gains its



Damaged SWR mooring leg

restoring characteristics from the mooring legs, consisting of an arrangement of chains and wire ropes. In the disconnected mode, the mooring buoy sinks to a predetermined depth. The mooring system in this mode is capable of surviving typhoon conditions.

Back-up system design

The back-up system is designed to be capable of retaining the FPSO in position and maintaining production, gaining time for ConocoPhillips to mobilize the required vessels and equipment to replace the broken wire leg, in case one of the wires fails due to its reduced strength.

SBM Services verified that the connector, and the back-up line in its new configuration, can withstand:

- The most probable maximum load at chain hawse e.g. 450 tons with a usage factor of $\eta_0 = 0.8$
- The most probable maximum load at chain hawse with one broken leg e.g. 580 tons with a usage factor of $\eta_0 = 1$

These usage factors have been defined by DNV.

One of SBM's main challenges was to design this special connector to be clamped onto an existing composite anchoring line and be able to withstand high loading as soon as the back-up line with Dyneema® has to take over the load in case of a SWR break. A finite element analysis was used to come-up with an optimized solution both in terms of mechanical strength as well as ease of subsea installation.

Rope production

Bexco nv, a Belgium-based rope manufacturer, designed and manufactured the back-up line from Dyneema®. Dyneema® was selected for this application over SWR and other synthetics because of its high strength and low weight. The 1000 ton MBL line consists of parallel laid cores of Dyneema® SK78 yarn protected by a polyester cover. Due to its neutral buoyancy the rope can be handled easily and safely by divers. The rope was designed for a minimum of one year under full load. Bexco and DSM Dyneema conducted creep analyses and used the results of this study in the design of the back-up line. The performance of ropes with Dyneema® is not affected by (sea) water, nor does it rot.

DNV approval

The design of the back-up system (connectors and back-up line) was reviewed and approved by DNV (Det Norske Veritas). The connectors were installed on each side of the steel wire rope, on the joining plate that connects the last chain link to the socket of the steel wire rope.

(Pre-)installation of the connector

It was decided to install back-up lines with Dyneema® SK78 on the SWR mooring legs #4 and #5 prior to regular maintenance to secure its operation. The back-up lines are intended only to take over the load in case one of the damaged mooring legs should fail and hence reduce the risk of lateral displacement of the BTM.

For ConocoPhillips the main reasons to choose Dyneema® were its low weight, neutral buoyancy and high durability and strength compared to alternative synthetic materials. Furthermore, the ability to do the installation job in a short as possible timeframe - as weather conditions did not allow for long installation times - played a role in the decision making process.

Diver support

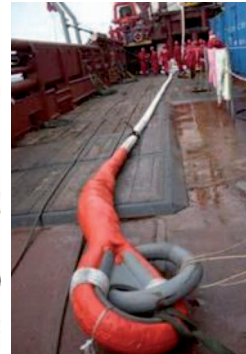
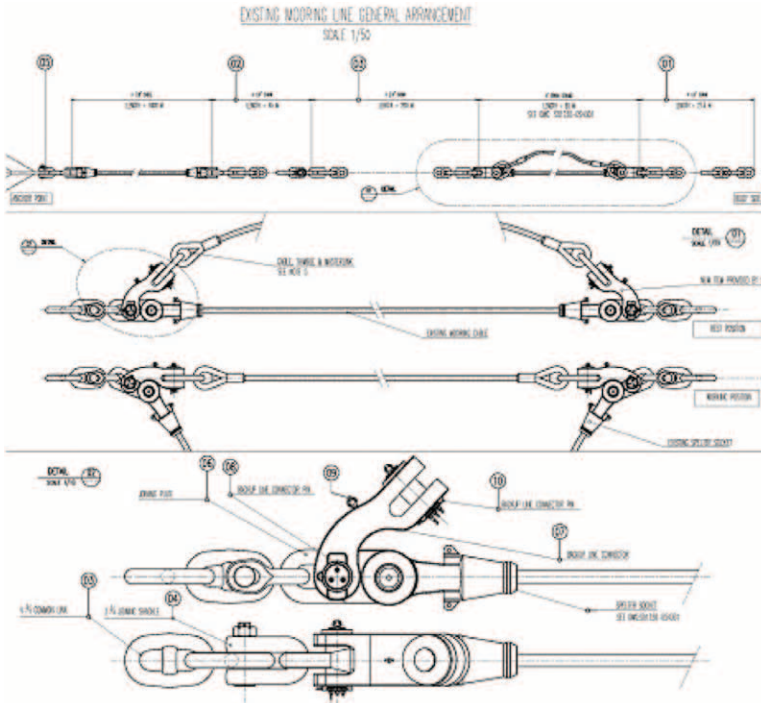
Installation of the back-up lines with a ROV was not possible because the ROV was not able to get close enough to the wires to perform the action. As an alternative, a crew of expert divers stepped in to mount the back-up lines with Dyneema®. Because of their neutral buoyancy the back-up lines with Dyneema® enabled the divers to do their job in a fast and safe manner.

De-commissioning the FPSO

ConocoPhillips has used the lines for 15 months to its complete satisfaction. FPSO NanHai KaiTuo was de-commissioned as of June 2010 and the back-up lines are now stored on-shore.

The project involved

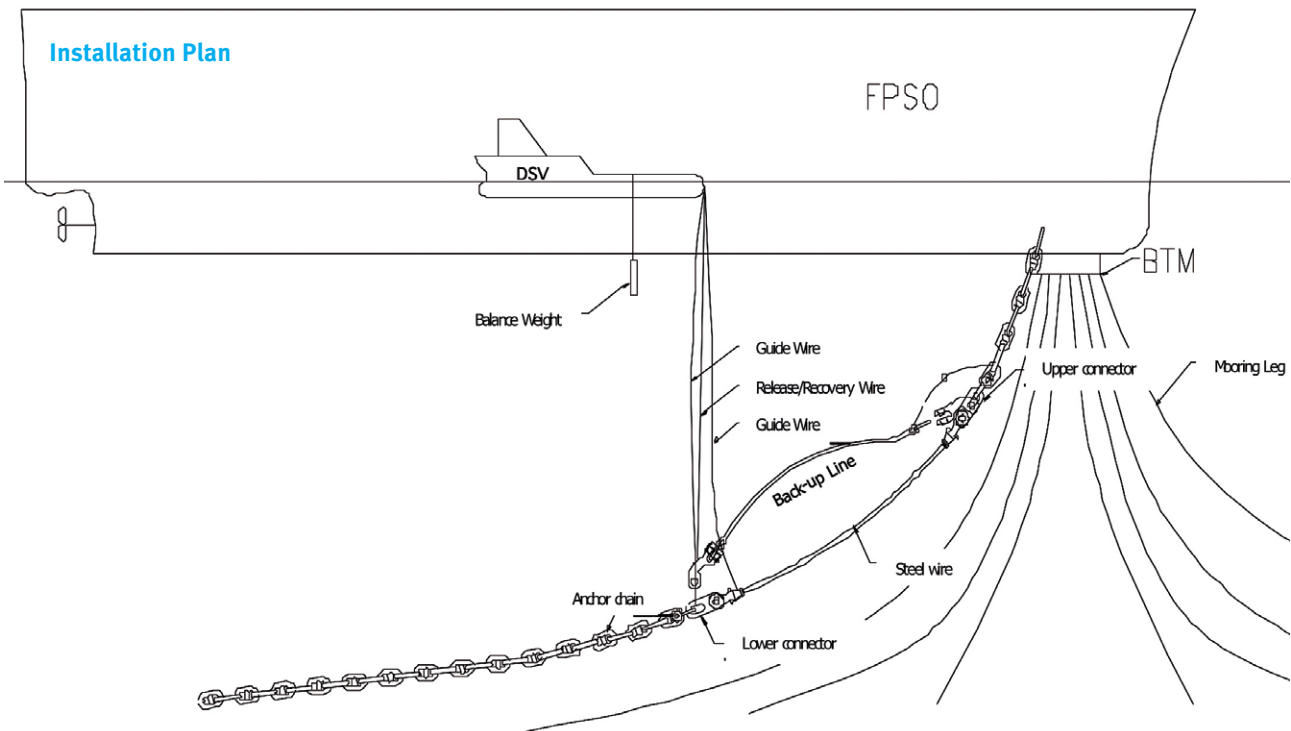
- four special connectors designed and manufactured by SBM
- two back-up lines with Dyneema® designed and manufactured by Bexco nv
- one Diver Support Vessel (DSV)
- a team of divers using Nitrox because of the depth they had to operate (85m below the water surface)
- a tug boat to turn the FPSO in order to



Back-up line with Dyneema® Mounted back-up system



Connector + back-up line



About SBM Services

SBM Services is one of SBM Offshore's seven operating companies and is based in Monaco. The unit comprises 4 departments providing specialized product services for the offshore oil and gas industry. Our departments are: CALM & Mooring Systems; Swivels & Mechanical Parts, including site inspections/interventions; Offshore Contracting and installation activities, and associated Marketing & Sales support, including After-Sales. In addition, SBM Services also manages the company's two offshore installation vessels: Dynamic Installer and Normand Installer. Together the four departments of SBM Services offer clients a fully comprehensive and integrated service.

About Bexco nv

BEXCO manufactures ropes for marine and offshore applications and is one of the leading suppliers world-wide. BEXCO is the result of the merger in 1999 between Le Lis n.v. and Vermeire nv, whose (traditional) rope making activities can be traced back to 1725. During the last 10 years BEXCO has evolved from a traditional rope making company to a high tech specialist rope maker for marine and offshore applications.

About ConocoPhillips

ConocoPhillips centers its business on one core purpose: to responsibly deliver energy to the world. To do this, the company finds, produces, refines, markets and ultimately supplies energy resources to individuals and businesses worldwide.

The company's four core worldwide activities include:

- Exploration and Production,
- Refining, Marketing Supply and Transportation,
- Natural Gas Gathering, Processing and Marketing
- and Chemicals and Plastics

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