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Unique small-footprint anchor handles extreme out-of-plane loading in high-uplift conditions

A diving anchor designed to contend with severe weather digs deeper in harsh GoM conditions.

By JUDY MAKSOUD MURRAY, Editor

In the Gulf of Mexico (GoM), environmental design criteria are based on historical hurricane data during storm season — June 1 through Nov. 30. Recent storms have been severe, causing significant damage to offshore infrastructure. In response to increased pressure for more stringent design practices, design codes have been modified, and there have been new technology advancements in many areas of the industry. One such area is station keeping design for moored floating structures.

Even before Hurricane Ivan in 2004, which caused significant damage in the GoM, Delmar Systems Inc. was already working on a new anchor design. The goal was simple — to create a more reliable and efficient foundation.

According to John Shelton, project manager at Delmar, the new anchor is a unique gravity-installed vertical load plate anchor with an innovative design that incorporates an omni-directional mooring arm attachment that rotates freely 360° around the axis of the anchor. "This is a key feature in extreme out-of-plane loading scenarios," Shelton said.

Rapid development for a demanding market

Anchor development began in May 2004 with Laponite-based laboratory testing. "Laponite is a clear silicate gel that allowed anchor behavior to be viewed under varied loading conditions," Shelton explained. The following year, Delmar completed its prototype and in early 2006 carried out the first full-scale offshore test with Shell.

"We gained valuable installation knowledge from the first offshore trial," Shelton said, "and the next year, we did two more full-scale offshore tests with Anadarko. At the end of 2007, we installed our first OMNI-Max that was connected to a MODU (mobile offshore drilling unit) in the Gulf of Mexico." This installation included a single anchor on one of eight mooring lines deployed over a four-month period.

Delmar secured patents for the anchor design and the original installation method in 2006 and deployed the first multiple-anchor system in early 2008, installing six anchors in complex soils for the *Ocean Valiant* for Anadarko. This was the first OMNI-Max application for use during hurricane season.

September of 2008 provided the first hurricane "test" when the *Amirante*, working for Eni Petroleum, withstood a direct hit from Hurricane Gustav while connected to a full set of eight OMNI-Max anchors.

"This is where the anchor really became a proven technology, and we confirmed our laboratory results," Shelton said. "When the anchor is loaded in a storm event, it initially rotates and reaches lateral equilibrium, and then dives to deeper stronger soils even when exposed to out-of-plane loading after one or more line failures." During Gustav, seven of the eight mooring lines failed. All anchors dove to deeper soils, and the last mooring line remained intact, holding the rig on loca-

The installation technique uses a 335 ft (102 m) section of strand-jacketed open braid rope attached to the mooring arm of the anchor. (Images courtesy of Delmar Systems Inc.)

tion while loading that anchor 180 degrees out of plane.

Unique applications

Ideal locations for the OMNI-Max in the GoM have typically been characterized as "high seafloor risk" locations, Shelton explained. Either the immediate area (within the mooring pattern) is congested with subsea infrastructure — meaning a higher probability of damage — or there are major production pipelines nearby that drive up the consequence side of the risk equation. These locations demand the utmost anchor reliability to minimize the risk of damaging subsea assets.

Frequently, operators need to work two wells in the same field some distance apart. Rather than move the rig's mooring system to the new location, it is more efficient to winch between wells on one mooring system without moving anchors. If the offset distance between wells is large enough, however, out-of-plane anchor loading becomes an issue.

In conjunction with insert wires, the OMNI-Max is ideal for large offset drilling applications. The out-of-plane and high uplift loading capabilities allow for the smallest mooring footprint design possible to achieve the desired rig offsets, which saves time in a drilling schedule.

Installation benefits

The OMNI-Max offers significant installation benefits over other preset anchor options, Shelton said. "The new patent-pending installation method makes the installation process very efficient." Average installation time for an OMNI-Max anchor is just under five hours in 3,000 ft (1,000 m) water depth.

The anchor is gravity-installed and does not require an A-frame. "We have an acoustic means of releasing the anchor from 150 ft (46 m) above the seafloor. There is also a manual backup that can be actuated by the ROV (remotely operated vehicle) if needed," Shelton explained.

The installation record to date includes an average tip penetration of 54 ft (16.5 m) in water depths ranging from 1,000 to 6,400 ft (305 to 1,951 m). According to Shelton, the maximum installation tip penetration on record is 66 ft (20 m). The ability to verify installation penetration (and thus be able to calculate the as-installed capacity) is a benefit over drag embedment anchors, Shelton said.

Other preset anchor options have limitations, but are suitable for less demanding conditions. For example, high-holding-capacity (HHC) drag embedment anchors are used around the world, but they have uplift limitations with respect to holding capacity. "They're typically used in systems with grounded chain to help keep the uplift low," Shelton explained.

Drag embedment vertical load anchors (VLAs) can be time-consuming to install and also impose a risk to underlying pipelines during installation. "They are pulled into place with a boat at a predetermined uplift, a process that requires a substantial amount of wire in deeper water," he said. "Installation in 8,000 ft (2,438 m) of water, for example, could require up to 15,000 ft (4,572 m) of wire to ensure proper embedment." It also requires high drum capacities and bollard pull, so larger boats that typically demand higher day rates are required.

Neither HHC drag embedment anchors nor drag embedment VLAs are ideal preset options for crowded seafloor conditions. Suction piles are excellent in congested areas that require high uplift load conditions, but they are expensive to transport and offer little out-of-plane loading capacity.

With the OMNI-Max installation methodology, there is no need for bollard pull, and the process requires only a wire length equal to water depth. "The added value of the OMNI-Max over suction piles is, of course, the extreme out-of-plane loading capability," Shelton said, "but the size difference is also important because it delivers logistical benefits. More anchors can be installed using smaller installation vessels in fewer trips."

The mooring arm attachment is on the side of the anchor toward the lower end for a more efficient use of available holding capacity. The anchor design also includes a top attachment point that is used for deployment and recovery. "Recovery is simple and quick," Shelton said. "Just hook into the buoyant recovery sling and pull upward with the vessel winch." The average retrieval force for non-hurricane loaded anchors has been about 135 metric tons at the anchor. E&P

The MODU version of the OMNI-Max anchor is about 30 ft (9 m) long, 10 ft (3 m) wide, and 10 ft high and weighs ~87 kips dry, about half the size of Delmar's typical MODU pile. The deck of the installation vessel can accommodate three to four times the number of piles with OMNI-Max anchors.