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VESSEL EXPERIENCE

DLB "Hercules" Reel / Tensioner System

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History

In 1990 Global Industries acquired the Reel Lay Barge "Chickasaw" from Santa Fe Pipelines. The "Chickasaw" had been laying pipe from it's horizontal reel since 1969 in the Gulf of Mexico and had laid many millions of feet of pipe up to the time of the acquisition.

The normal mode of pipe laying for the "Chickasaw" entailed setting up at the initiation point on anchors, tying the pipeline off to a structure or some anchor point, then slipping anchors and pulling the barge down the route with a tug while laying out pipe. While this method was successful, it had a number of shortcomings. These included the ability to control pipeline tension accurately, the ability to lay the pipe on a precisely controlled route, and handling anchors in close proximity to congested structures.

In order to overcome these problems, plans were put in place shortly after the acquisition to enhance the barge's capabilities by the upgrading it with Dynamic Positioning. The project to install a redundant DP system on the "Chickasaw" began in 1993. In August of 1994 the "Chickasaw" began, and completed, the first of many successful projects utilizing Dynamic Positioning. That project included close to 500,000 feet of 2" pipe, 6" pipe and umbilical. Water depths for the project ranged from 400' to 800'. The pipeline route traversed an environmentally sensitive area, which required that the pipeline be laid very accurately to minimize damage to coral heads. The project was successfully completed in two trips offshore with a total duration of 22 days.

Subsequent projects on the "Chickasaw" proved to be highly successful. The "Chickasaw" has to date, completed multiple deepwater projects installing pipelines, subsea completion skids, umbilicals, and jumpers in water depths out to 5300'.

The "Hercules"

Drawing upon the success of the "Chickasaw", Global has sought to capitalize upon the experience gained in deepwater operations. As a result, Global acquired the Derrick Barge "Hercules" in 1995 and began to lay plans to upgrade the barge with Dynamic Positioning.

With project engineering beginning in the fall of 1996, the "Hercules" conversion began. Conversion was completed with successful sea trials and subsequent conventional pipeline and heavy lift projects beginning in the summer of 1998.

The "Hercules" Reel / Tensioner System

From the inception of the "Hercules" conversion project plans were in place to build a reel system similar to the "Chickasaw" reel. The system envisioned would be required to lay pipes up to 18" diameter in water depths up to 8000'. This system would include redundant 600 KIP tensioners. Additionally the tensioner system would be required to lay large diameter pipes by the conventional stovepipe method.

Project engineering on the reel portion of the project began in the summer 1997 culminating in the letting of a contract to design and build the system in November 1997. The system was fabricated in Scotland and delivered to the Global yard in Carlyss, LA in the fall of 1998. Due to market economics installation of the system was delayed until spring of 2000. System installation was completed and sea trials held in September 2000.

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Pipeline Methodology

Installation of offshore pipelines is most often accomplished by one of two means, the conventional stovepipe method or the reeled pipe method. Both methods require that the platform from which the pipe is laid be capable of maintaining enough tension in the pipe to prevent the pipe from kinking. The tension required is a function of the pipe diameter, wall thickness, metallurgy, and water depth. Tension is also affected by whether the pipe is flooded or dry. Additionally, the platform from which the pipe is laid must be capable of moving along a predetermined fixed corridor. This movement until recently was most often accomplished by crawling a barge or ship along the right of way with anchors. Presently there are a number of Dynamically Positioned pipeline vessels of various types throughout the world.

Conventional stove piping is accomplished by welding joints of pipe end to end while offshore. In the normal configuration a joint of pipe is welded to the preceding joint while passing through a series of welding stations. Each station is responsible for some portion of the full weld. The vessel is moved forward by one length of pipe when each station has completed a portion of the completed weld. Additionally, there are stations to test and coat the welds.

Tension is maintained in the pipeline by a tensioner system. This system squeezes the pipeline between tracks. The tracks have rubber-coated pads affixed. The track system is squeezed against the pipeline by air pressure to obtain frictional adhesion of the pads to the pipeline. Load cells sense pipeline tension. A predetermined tension is set into the system with some reasonable deadband. As tension increases in the pipeline the system will pay out or pick up pipe to maintain the preset tension.

Reeled pipe systems are of two basic types, vertical and horizontal. Both systems function by reeling pipe that has been welded on a spool base into long stalks. Each stalk is reeled individually then welded to another to form a continuous length of pipe. After reeling pipe the vessel proceeds to an offshore location and lays the pipe in a continuous pipeline.

Pipeline tension on reeled systems is maintained either by the reel itself or with the addition of pipeline tensioner systems. Pipeline tensioner systems are added to reel systems to prevent the tension in the pipeline from deforming the roundness of underlying layers of pipe. Pipe that has become oval from the pressure exerted by tension on the reel is subject to being crushed by water pressure in deeper water.

One of the more critical aspects of pipe laying is managing the stress in the pipe as it departs the vessel. There are two basic methods in common use, J-lay and S-lay.

J-lay systems normally have a departure angle from the vessel of between 0 and 15 degrees from vertical. This means that conventional stovepipe systems must weld pipe in a vertical configuration. Most reeled pipe J-lay systems rely on vertical reels. Stinger lengths to support the pipelines are minimal. A single bend point in the pipeline characterizes this pipeline installation method. This bend is just above the sea floor, hence the name, as the pipeline profile resembles the letter “J”.

S-lay systems allow pipe to be welded in a horizontal configuration, but require stingers to support the pipe profile as it departs the vessel. Departure angles can vary. S-lay pipelines are characterized by two curves in the pipe. The stinger at the surface manages one curve; the other curve is just above the seafloor. The pipe profile resembles an “S”.

Systems that utilize the J-lay method must manage tension in the pipeline that is mainly in the vertical. S-lay systems must manage tension in both the vertical and the horizontal. This can have a significant effect Dynamic Positioning, as horizontal tension is absorbed as environment.

Pipeline Systems Comparisons

Conventional stovepipe pipe laying systems rely on field welds made in an offshore environment and therefore suffer from quality control issues. These systems also rely of a large amount of logistical support and material handling. Time in the field for equipment is expensive and weather becomes an issue.

Reel type systems reduce the offshore material handling. Welds are executed in controlled environments with repairs having minimal impact on production. Due to the speed with which pipes can be laid out, vessels are able to pick weather windows, thereby minimizing offshore costs.

Reel systems are limited by the diameter of the pipe to be reeled. Pipe sizes beyond 18” are impractical for reeling due to the minimum radius required for the spool hub. Spooled pipes are also subjected to multiple bending cycles, which must be carefully controlled to insure that the pipe is not over stressed.

While both horizontal and vertical reels are in use throughout the industry, vertical reels are limited in capacity by the bearing sizes required to manage the weight of the pipe. Vertical reels also have a more significant effect on the vertical center of gravity of the vessel on which they are installed. Load on horizontal reels can be managed with a series of wheels and rails while utilizing a center bearing which does not support the entire weight of the reel and pipe. With notable exceptions most vertical reels in use are designed for pipe diameters 8” or less. The Hercules system horizontal reel is designed to reel 18” pipe. The inner hub diameter varies from 59' to 64'. Accommodating a hub diameter of that magnitude in a vertical reel would not be cost effective.

The Hercules Reel / Tensioner System Capacities

The Hercules Reel / Tensioner System was designed with the intention of addressing the needs of deepwater pipelines. As water depths increase, the amount of unsupported pipe between the vessel and the sea bottom necessarily increases. As a result, the tension absorbed by the system must increase. The Hercules utilizes an S-lay configuration. The tension that must be absorbed includes both the submerged weight of the pipe and the tension required to maintain the proper S-bend geometry.

In pipeline terminology, “Top Tension” is the vertical component of the tension, while “Bottom Tension” is the horizontal component. The combination of the two is referred to as “Total Tension”. On a Dynamically Positioned Vessel, the DP system only responds to ‘Bottom Tension”, whereas the reel or tensioners must respond to “Total Tension”.

Each tensioner in the Hercules system is capable of absorbing 600 kips of total tension. Therefore, in tandem the systems tension capability is 1200 kips. The additional tension capacity of the reel is a function of the moment arm resulting from the number of layers of pipe on the reel.

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The reel system is capable of holding varying lengths of pipe depending upon pipe diameter. The reel capacity ranges from 84 miles of 6” pipe to 10 miles of 18” pipe.

System Components

Systems components include; the reel, the straightener / aligner platform, two tensioners, and three roller supports.

The reel outer diameter is 116’. The core of the reel is tapered with an upper diameter of 59’ and a lower diameter of 64’. The distance between flanges is 25’. The outer diameter of the reel has a bull gear affixed. There are four 280kW DC motors, which drive the reel through a planetary gear and speed change box. Motors are driven by regenerative four-quadrant control SCR systems. The reel is designed to skid onto and off of the barge. This allows the barge to be reconfigured for conventional pipelay projects using pipe diameters up to 60” with 6” of cement coating.

The straightener / aligner platform guides the pipe onto the reel. The system consists of three tracks, two of which are on one side of the pipe with the third on the other side. The tracks can be moved to accommodate different pipe sizes. The tracks are used to guide the pipe onto the reel and to straighten the pipe as it leaves the reel.

With the exception of the reel, all system components must fleet (level wind). This is required to level wind the pipe both on to and off of the reel. The system is designed to fleet on predetermined pipe geometry. The six components that fleet do so based upon a look up table. The operator raises the straightener / aligner platform to keep the pipe wrapping evenly on the reel. The tensioners and roller supports follow based upon the look up table providing support for the pipe.

Modes of Operation

The reel / tensioner system components can operate in either speed control or tension control. The tensioners derive feedback for speed from track speed encoders. Tension feedback is developed from load cells on the system. Due to the varying diameter of layers of pipe on the reel speed is calculated by keeping track of the number of layers of pipe on the reel. The diameter calculation is used in conjunction with the motor speed to calculate the pipe speed. Reel tension is resolved from the motor armature current.

When reeling pipe the reel is placed in “Haul In” using speed control. The tensioners are placed in tension mode to hold back enough tension to keep the pipe wraps even and supported. When laying pipe the system can be operated in “Payout” mode with either speed or tension control. The tensioners pull the pipe off of the reel until the total tension overcomes the system friction and inertia. The tensioners then begin to hold back tension based upon either the speed control algorithm or the tension control algorithm. The reel operates in tension mode to maintain tension across the span from the outer layer of pipe to the straightener / aligner.

Technology

The Hercules reel/tensioner system utilizes twelve DC motors driven by four quadrant control regenerative SCR drives. The drives are Eurotherm 590 series machines. Each drive has

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the ability to act as a master or slave. Four motors are installed on the reel and each tensioner. The motors are used to both power and brake the system. Each motor has a disc brake attached. These disc brakes serve to park the system and act as emergency brakes.

The Hercules power buss configuration conforms to ABS DPSIII. There are two split secondary feeder transformers for the reel / tensioner system. These transformers are designed to introduce phase shifts in the system current, thereby reducing total harmonic distortion. Each transformer is located in a physically separate space and fed from separate switchboards. The loss one switchboard compartment or transformer compartment will not affect the other. The system can therefore sustain the loss of a compartment and maintain 50% capacity.

The SCR systems are arranged with three drives in four insulated air-conditioned containers. Each container is fed by one secondary from the split secondary transformers. Transformer output to each container is isolated through a breaker. The three drives in a container each operate one motor on the reel and one motor on each of the tensioners.

The Eurotherm drives are programmable and have standard blocks for tension control, speed clamps, winder functions, etc. The system software takes advantage of the programmed blocks within the SCR systems. Supervisory control and outer loop PID control is affected by Opto22 distributed control technology.

Control input and display is handled through the Pipe Control Console (PCC), which includes both conventional push button and meter displays. A CRT displayed mimic developed in Opto22 Factory floor is also provided. The system is fully programmable and tunable through a keyboard in the PCC.

The reel/tensioner system and the DP system share data. There is a pipe speed output fed to the DP system from the PCC and a speed down track output fed from the DP system to the PCC. Each system displays the information from the other for the operators. While it is possible to automate the process by programming one system to drive the other, there are presently no plans to do so. All system controls are designed to insure that the operators remain involved in the process. The DP System and PCC are in the same room insuring that the operators have good communications.

Reel/Tensioner Operators and DP Operators will be cross-trained. When the system is in operation there are always three operators / technicians available as well as supervisory personnel. All three operators will be capable of operating either system or in an emergency situation both systems at the same time.

Sea Trials

Upon completion of dock trials, approximately 5000 feet of 12” pipe was reeled onto the system. The Hercules mobilized to Keithley Canyon Block 317. In water depth of 6000’, the pipe was initiated flooded and unreeled in a simulation of normal pipe laying conditions.

Throughout the sea trials various control modes were exercised. The Master / Slave relationships were varied so that the reel and both tensioners were each used as master. The system was operated in speed mode and tension mode.

The pipe was successfully laid out and recovered with a total system tension in excess of 425 kips. Total elapsed time from initiation to recovery of the pipe was less than 12 hours.

Conclusion

The Hercules reel/tensioner system is the largest such system ever built. It was recognized from the start that there would be a significant learning curve both in the design stages and throughout the initial operation of the system. The system design philosophy was to design a system that would be easily configurable and adaptable to varying pipelay requirements.

The Hercules reel/tensioner system has fulfilled it's original design philosophy. The system is capable of reeling and laying pipelines of varying diameters to water depths in excess of 8000'. It provides a fully programmable and adaptive system, which can be tuned for varying conditions, thereby providing a fast effective means of installing offshore pipelines.