Understanding dynamic positioning

DP SERVICE Demand for specialised DP vessels, which are required for different environments and purposes, has increased significantly over recent years. UK-based LOC Group, an international marine and engineering consulting firm engaged in shipping and offshore energy, specialises in the assessment of all kinds of DP vessels. Sen Abhayasinghe, LOC's Group Technical Authority DP Services, describes how DP is used and how the different classes can be characterised.

Dynamic positioning (DP) is a computer-controlled process which enables a vessel or a rig at sea to maintain a predetermined heading and position whether fixed or moving. The vessel or rig can be safely and accurately controlled using its propellers and/or thruster systems to generate power that nullifies the effects of environmental forces – predominantly wind, current and wave action.

Continually maintaining the accuracy of position-keeping depends on the availability and reliability of thrust power and the magnitude of environmental forces acting upon the vessel. The DP system monitors the vessel and its surroundings using a variety of sensors. These include position reference systems to pinpoint a vessel's location with a fixed or relative reference and gyrocompasses as a heading reference, along with other environmental sensors, such as motion reference units (MRU) and wind sensors. The data is used to build a mathematical model of the vessel, which is processed and the results applied, to give a vessel that is automatically positioned.

The DP class categories

A vessel can be adapted to become a DP vessel; however, the extent of upgrade will depend on the status of the systems and number of thrusters already available. DP comes in three categories with complexity of design and cost increasing depending on the system and operational requirements.

DP Class-1 vessels are not required to have redundancy and so a single failure may result in insufficient thrust to hold its position.

For DP Class 2, loss of position will not occur in the event of a single fault in any active component. Normally static components will not be considered to fail where adequate protection from damage is demonstrated, and reliability is to the satisfaction of the certifying administration.

In addition to the requirement for DP Class 2, a DP Class-3 vessel should not lose position as a result of a single failure in any static component, watertight compartment, or any one fire subdivision from fire or flooding.

The use of DP vessels has increased significantly over recent years. These specialised vessels are often required for different environment areas and industrial missions. These include medium-to deep-water drilling, accommodation, construction, removal operations, wind turbine installations and services, subsea activities (divers and ROV operations), pipe and cable-lay operations, shuttle tanker operations, automated thruster assisted moorings and weather-vane operations.

DP2 and DP3 vessels should not lose position as a result of a single failure, so a DP vessel should be selected for a particular task, depending on the risk of losing position during the intended industrial mission.

There are maximum environmental conditions under which a DP vessel can maintain its position and heading. The maximum environmental conditions (wind speed/direction sea current speed/direction and wave height/direction) with all the equipment intact will reduce when the vessel is subject to a single failure causing reduction of thrust.

Reduction of thrust could be a result of failure of electrical power, the control system or any other failure affecting thruster performance and/or a failure of a thruster itself. A capability analysis is conducted using software to determine the environmental limitations which are based on a number of factors including available thrust power, size of vessel and forces of industrial mission – for example, pipe tension of a pipelay vessel.

Another important document associated with DP systems is the Failure Mode and Effect Analysis (FMEA). FMEA is a structured engineering analysis of systems, subsystems and components intended to identify any single failure that would cause a DP vessel to lose its position by drift-off or drive-off. LOC has extensive experience in performing FMEA on all kinds of DP vessels including highly complex vessels.

DP in practice

LOC recently advised on two projects involving platform removal and installation using the DP3 vessel *Pioneering Spirit*, the largest construction vessel in the world.

Pioneering Spirit entered into service in 2016 and offers a step-change in offshore installation and decommissioning. It is capable of lifting entire platform topsides of up to 48,000 tonnes and jackets up to 20,000 tonnes in a single piece. For jacket removal and installation, the two 170m-long lifting beams can rotate on hinges located at the vessel's stern and a 5,000-tonne special- ›

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The DP2 wind farm service operation vessel *Windea La Cour*

purpose crane offers additional lifting power for lighter topsides and jackets, modules and bridges.

The twin-hulled vessel can move around a platform and lift and transport entire topsides using eight sets of horizontal lifting beams. Eight diesel generators provide 95 MW of power, driving twelve azimuth thrusters for DP3 operation and propulsion.

The project that LOC advised on involved the removal of a platform, its topside and later the legs. Using its DP capability, *Pioneering Spirit* went alongside the platform, and the lifting beams extended under the topside of the platform to take the weight. The DP enabled the vessel to hold its position to a 20 to 30cm accuracy, keeping in position for as long as the marine operations required. The weight of the platform had been calculated and added to the DP programme, which meant that the additional weight was not interpreted as an external force such as a wave. This would have led to the DP system compensating to maintain its exact position.

The biggest advantage that DP offers to the installation and decommissioning process is that the entire platform can be removed in one piece, dramatically reducing the amount of offshore work. Before DP, the infrastructure would have been dismantled in situ, bit by bit. Moving the work onshore offers significant savings in terms of time and cost, and is safer for those involved.

On any project, LOC's DP specialists review assurance document such as DP FMEA, DP proving trials, DP annual trials and operational procedures, ask additional questions to complete numerous risk assessments, all with the aim of identifying, reducing and mitigating risk, and modifying actions to complete the project effectively and safely. Any lifting operation runs the risk that the infrastructure could be lost into the sea, so it is vitally important that the holding and side positions are maintained for the duration of the project, and a DP-equipped vessel with adequate capacity provides this certainty.

LOC has also assessed *Pioneering Spirit* for its suitability for pipelay operations, using DP in the Black Sea. It is the biggest pipe-laying vessel in the world, capable of installing record-weight pipelines in all water depths. The pipes which are 38" in diameter, were being laid in water more than 2,000m deep, along a preplanned path. An initial survey was completed – using a DP survey vessel – then the path was set, and the pipes laid, while the vessel moved along the exact path.

Subsea cable lay operation is similar to pipelay operations. After conducting a seabed survey, the cable lay paths are decided and a cable lay vessel is used to lay the cables. The laying of array cables has increased significantly due to high demand from wind farms. This type of cable laying is performed in shallow water and can be performed using DP vessels or mooring barges. These vessels use a plough and trenching process to bury cables in the seabed, and to cover and protect the cables.

Mooring barges need to be carefully managed for seabed obstructions, as their anchors may damage pipelines and subsea cables already in place. However, by using a DP vessel alongside, the mooring barges can still operate and thanks to the DP vessel, can maintain an exact and precise position to lay the cables.

DP vessels are also used for wind turbine installation and windfarm maintenance where walk-to-work gangways connected to the installation allow the engineers access for maintenance.

DP is particularly valuable where the waters are congested and losing position could mean the possibility of colliding with another vessel. It is often used by cruise ships when berthing, or where a vessel is too large to manoeuvre safely in relatively small spaces or around other vessels. DP is also used by cruise liners to maintain a constant position in open water where an anchor would drag, harming objects on the seabed, enabling passengers to be taken ashore on smaller boats.

› DP HISTORY

Dynamic positioning systems were developed in the 1960s to enable the recovery of sedimentary core material from the deep seabed.

The seabed needed to be drilled to reach hydrocarbons, but jack-up barges and anchoring systems couldn't be used economically at the depths required, and so the challenge was to invent a mechanism to position a drilling vessel over a bore hole on the seabed.

As a near solution to this issue, the vessel *CUSS 1* was developed by converting a barge and fitting a direct engine-driven thruster near each corner of the vessel. The design intent was to hold the position of the vessel manually within a 180-metre radius.

The first vessel to be built with automatic positioning capability was Eureka in 1961. It was fitted with electrically driven thrusters located fore and aft. Howard Shatto pioneered the development of an automatic dynamic positioning control system using three analogue controllers for controlling surge, sway and yaw. This was improved further with the application of a digital DP control system on drillship *Glomar Challenger* in 1966.