Operational Experience with Dynamically Positioned Diving Support Vessels

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SYNOPSIS

Experience over the last few years has ranged from the Stadive *to converted supply boats; from a semi-submersible with the world's largest civilian diving spread, provided with twin moonpools and a manned lockout submersible, to a single chamber diving system with a bell lowered over the ship's side. What all these vessels share is the requirement to operate with full redundancy, so that any single failure (mechanical, electrical or instrumental) will not result in a loss of station keeping capability or at least not until the divers have been safely retrieved. The author describes how procedures and standards have been developed both to determine the safe level of redundancy for any prospective or existing DP diving vessel and to assess the capability of a new custom-built vessel.*

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INTRODUCTION

Shell International Marine Limited, as the name implies, becomes involved in world-wide marine activities, primarily in a consultancy role for other Shell companies; an increasing number of which involve dynamically positioned (DP) vessels.

On a routine basis we provide an inspection and analysis service on DP diving support vessels (DSVs) being offered on charter. The requests for our services come from the diving advisors (for both underwater maintenance work and, via the project teams, for underwater construction and pipelaying work) and relate to the capability of the DP system for both diving and working close to a platform. With the continual increase in seabed obstructions and installations it is becoming more difficult to employ an anchored DSV; in many cases, it is essential that a DP vessel is used. Examples include pipeline tie-in work close to production jackets, and the Cormorant Central UMC (underwater manifold centre) with its radiating flow and control lines.

The increase in safety standards and regulations means that it is not sufficient for us to demand of a vessel's owner that it be safe for DP diving and meet the regulations. The charterer also has a responsibility to ensure that the vessel meets these standards. Within Shell companies, an incident on a contractor's vessel will be reported as occurring adjacent to a Shell installation on a Shell oilfield. Therefore, to guard against such an event, the only way is to satisfy ourselves that the vessel meets all the criteria laid down for it, including the charterer's requirements.

GENERAL EXPERIENCE

Two terms often used in assessing the reliability of DP systems are 'redundancy' and 'single point failure'. Redundancy means that all critical parts of the system are duplicated or backed up by auxiliaries, e.g. dual DP computers, at least two position sensing systems and multiple thrusters. Single point failure refers to any component which could effectively result in loss of position keeping ability: a simple example would be a single power supply to all thruster control panels, where one fuse could fail all thrusters.

In addition, the term 'hidden failure' is used, where a component is not in itself critical but, if it fails, could leave the system open to a single point failure. An example would be the low level alarm on a cooling water system header tank. If the alarm sensor should not operate there would be no warning of a loss of cooling water and, hence, electrical generating plant.

Experience on many vessels has shown that the areas which are least likely to meet the requirements of a fully redundant DP vessel are not those in the centre of the system. The DP control system, if bought from one of the major suppliers as a duplex system, is likely to require less attention than the support systems: in particular the fuel oil service and cooling water systems, the electrical distribution system and the position reference system.

Examples of problems found in such areas are various, but tend to be of similar type. The following give an idea of the kind of design faults and single point failures we have encountered during our experience in DSVs.

Fuel system

On many vessels a common fuel tank is used to supply all the diesel engines (either to generate electricity or to drive propellers and thrusters directly); often the second tank, if fitted, is not on line but used for settling out bunkers. Obviously, in such a situation a loss of fuel or slug of water can result in a loss of all engines. On a newbuilding, such a situation can be avoided by splitting the fuel tanks and providing duplicate fuel supply lines; but on an existing vessel or a conversion the cheapest remedy is to install both low level and water detection alarms. All operators will state that fuel tanks are checked regularly for both level and water content. However, no one can guarantee watchkeeping to be infallible and the provision of these alarms reduces the risk of single point failure.

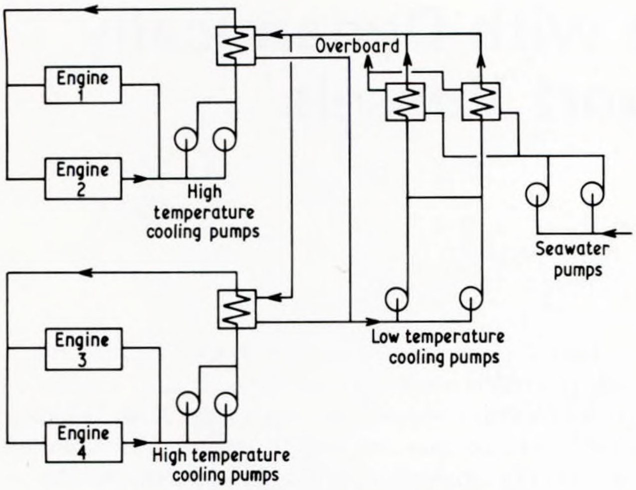


FIG. 1 Example of cooling water system

Cooling systems

For economic reasons, diesel engines and thrusters often share a common cooling system. While the ideal arrangement for redundancy would be separate systems for each engine, this would increase the capital cost and the maintenance load and probably clutter the engine room. There is a compromise which depends on the balance of economic and practical considerations, and on the thermal inertia of the system.

As an example of the latter, consider an engine room with four engines, with two high temperature cooling systems and one low temperature cooling system (Fig. 1). The thermal inertia of the low temperature system is very high such that, if the sea water cooling were lost, the natural radiation and conduction in the system are likely to prevent problems (certainly in the cold North Sea). Similarly, if one of the HT systems gives trouble only half the engines need be stopped.

However, if the LT circulation were to be stopped, the lack of cooling of the HT systems would result in all four engines tripping very quickly (a matter of 2 or 3 minutes at the most). In this kind of situation a working standby pump *must* be available at all times. This system requires comprehensive alarms and monitoring to warn of any hidden faults, which could result in a loss of redundancy and potential single point failure.

Electrical distribution

When assessing the reliability of the electrical power generation and distribution system, it is important to take into account the consequential effects of fault levels and tripping actions. A high degree of professional knowledge and experience is necessary in this assessment, and we have been surprised at the high incidence of DP vessels where the operators (and, apparently, in some cases the designers) do not appreciate the potential problems that can arise.

A typical system used on DSVs is shown in Fig. 2. The primary and secondary bus voltages vary depending on the number and size of the consumers, but may be 6 kV/440 V, 600 V/440 V or 660 V/440 V. In this system a busbar fault on any of the four sections (R, S, U or V) will shut down only its own section (assuming the correct settings for busbar couplers and both transformer and generator circuit breakers). As long as the distribution of load is balanced on each side of the switchboards, it should be possible to avoid loss of position on DP.

In one particular case, 'coupler' Z was actually a solid link between the two sides of the secondary bus, and a short circuit on either section U or V would inevitably cause a total loss of the secondary voltage system, resulting in loss of DP. The correct solution here is that Z must be a circuit breaker. Alternatively, on a temporary basis the links could be removed, which would give the required electrical isolation in the event of a fault. However, this results in a loss of flexibility in the event of one transformer failing.

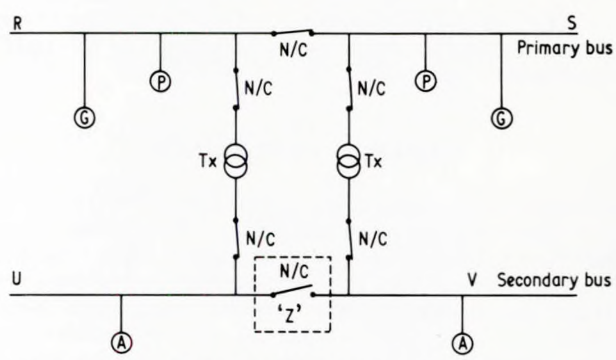
Position reference system

Most diving vessels operating in the North Sea on DP now have a minimum of three position reference systems fitted: typically, a taut wire, an acoustic system and a radio reference system. Our experience is that it is impossible to have too many sensing systems, as any of them can be out of service owing to maintenance requirements, environmental interference or (in the case of radio systems) shadow effects.

Actual experience has shown the following effects on position reference systems:

1. *Taut wires*. Preventive maintenance is essential to avoid sticking of the wire, or breakage and loss of the weight. Stickiness in the constant tension device can cause a false position signal or, worse, dragging of the weight.
2. *Acoustic systems*. With the latest electronic filtering techniques the ultra-short baseline transducers (fixed or tracking) and transponders probably provide the most reliable system, except in applications with severe aeration problems. Modern equipment can allow up to nine frequencies, permitting a high degree of flexibility in application.
3. *Radio reference*. Short range systems are very accurate and have the great advantage of absolute measurement from fixed stations, as opposed to the taut wire weights and transponders which are deployed from the DP vessel itself. However, Syledis beacons are often located on top of drilling derricks (which are moved periodically) on production platforms, and the portable halves of short range systems (Artemis, Motorola etc.) have been known to move or switch themselves off!

Taking these factors into account, each vessel is going to have to select a mix of position reference systems to suit its own particular application. Our advice on a basic selection would be two taut wires and an acoustic system with dual transducers, both with the maximum possible physical separation, together with one or two radio reference systems suitable for the area of operation.



G = Generators (two or more each side)
P = Propulsion motors (two or more each side)
Tx = Transformers
A = Auxiliary services (cooling water, fuel, hydraulics etc.)

FIG. 2 Example of electrical one-line diagram

SHELL/ESSO MSV 'STADIVE'

Shell International Marine was involved from the early design stage of the multifunction service vessel *Stadive* and worked very closely with the vessel's designers (Thor Haavie and Seaforth Maritime Limited) to ensure that the operations would be as trouble free and reliable as possible. From the viewpoint of the DP capability, this involvement encompassed the DP system, the electrical power system and the mechanical engineering aspects of the thrusters and diesel generators. As a demonstration of the total systems engineering approach, the following studies were among those carried out during the conceptual and design stages of the vessel's development:

1. Failure modes and effects analysis covering all systems relating to DP and firefighting.
2. Static and dynamic computer simulations of the DP performance, using the mathematical model generated by GEC Electrical Projects, Rugby, from the model test data; including failure conditions.
3. Computer simulation of the 6 kV electrical power system under transient and dynamic load conditions.[1]
4. Cooling water system computer calculations to prove the pump loadings and pressures, under normal and emergency running conditions.

Naturally, the sea trials on such a complex vessel were considered to be of paramount importance, not only in proving the installation and design concepts but also in setting up the operational procedures and limitations. A very comprehensive trials programme was developed through the joint efforts of all involved, which listed all tests required to prove the capability of the vessel, in terms of both the optimum performance and the system reliability in the event of faults. Full records were kept of all tests, which were very valuable during the subsequent shakedown of the vessel. The DP trials section of the trials took about a week to complete, although some other system trials were conducted in parallel.

During *Stadive*'s operation in the Red Sector of the North Sea (the north-east Shetland basin), the operators have continued to gather information on its performance, which has increased their awareness of the vessel's capabilities and limitations. As the long term charterers of the vessel, Shell UK Exploration and Production Limited has a continuing role in monitoring the performance of *Stadive*, to ensure that the standards of operation are maintained or, if necessary, enhanced.

CONCLUSION

During the last two years our experience in surveying DP vessels has enabled us to develop our own guidance document and checklist. At the request of the Diving Advisory Group of UKOOA (the United Kingdom Offshore Operators Association), we used it as the basis to prepare a guidance document and checklist which could be used by its members to assist in the assessment of the DP capability of DSVs. It was approved by UKOOA in March this year.

Our work in this area is often carried out as Consultancy and Technical Services (abbreviated as CTS), which is a division of Shell International Marine. CTS was set up some years ago as a service to third parties and to consortia in which there is a Shell interest.

REFERENCE

1. J. R. Smith, A. F. Stronach and A. T. Mitchell, 'Prediction of the electrical system behaviour of special purpose vessels', I. Mar. E. Conference on Future Electric Propulsion for the Marine and Offshore Industries, London, 4 December 1984, *Trans. I Mar E (C),* Vol. 97, Conf. 3, Paper 2.