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Risk Management

Improving DP Operational Reliability through Application of the IMCA FMEA Management Guide

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Introduction

Wavespec has been working over many years with providers of offshore drilling and platform support services to review the status of DP documentation and operations on their vessels, particularly on vessels either built before the most recent DP regulations or that have been subject to upgrades. In many of these vessels there is either an insufficiently detailed FMEA document, or one which is seriously out of date.

In a number of cases potentially serious DP incidents have occurred, which have triggered a response from the vessel owner or operator and the subsequent investigation has identified a number of deficiencies, which require corrective action.

This paper will review one or two of these original incidents and focus on the methodology used (based on the FMEA Management Guide published by IMCA in April 2005) to review present DP FMEA documents and update them, as well as the improvement of onboard knowledge and hands-on experience of possible incidents and failures.

Background

Dynamic Positioning (DP) started to be applied to offshore oil industry shipping on a large scale in the early 1980s, particularly with the exploration of the North Sea and other deeper water oil and gas fields worldwide. The initial DP system development had, of course, begun in the USA with drilling ships in the late 1960s and early 1970s. The first such systems were often prototypes that were designed and operated by a dedicated group of individuals, sometimes under government supported contracts, and it was not until the rapid commercialization of the subsea construction and maintenance industry in the late 1970s that a clearly defined and structured DP industry developed.

The author was first introduced to the mysteries of DP in about 1979, when Shell and Exxon decided to build a multi-function support vessel MSV Stadive for the Brent Field sector of the North Sea. Until that time, DP stood either for differential pressure or data processing, but the learning process for the design and specification of the Stadive (now reincarnated as the drilling semi Louisiana) included meeting and visiting the three major manufacturers bidding at that time to supply DP systems – GEC, Honeywell and Kongsberg. Interestingly, there was no guidance or standard available to follow at that time, only common sense and empirical experience from the pioneers.

The Stadive was built in Finland with a GEC DP system and we believed it was analysed and tested to the ultimate level of safety at the time. However, a number of incidents, mostly minor, occurred over the first few years of operation which alerted us to the potential weaknesses in our approach to analysis at that time and to the development of failure modes and effects analysis (FMEA) in other industry sectors such as aerospace and nuclear power.

The oil majors started at that time to take an ever-increasing interest in evaluating and testing the DP capability and robustness of the offshore vessels offered to them for charter, and the UK Offshore Operators Association (UKOOA) developed guidance notes and a checklist for assessing and carrying out audits – particularly for diving support vessels (DSV). This was not the first such document but, being issued in about 1984, it became the de facto industry standard for a number of years, until the DP Vessel Operators Association (DPVOA) revised it and brought it in line with the classification society and regulatory authority guidance.

In the last ten years the International Marine Contractors Association (IMCA), with whom the DPVOOA merged in the mid 1990s, have taken over the role of issuing guidance to their members on a wide range of issues including DP and allied topics. The author's company is one of those that has contributed to this guidance, and recently was commissioned to create a high level FMEA Management Guide that seeks to assist both owners and operators in assessing the condition of their DP vessel reliability and performance, and correcting any deficiencies found.

Some More History

As stated above, the first DP audits were carried out by the oil majors before taking a DP vessel (usually involving diving operations) on hire. However, this rapidly grew into the situation where some vessels spent more time being audited than they did working, and they weren't paid for it! Out of this chaos the DPVOOA developed a system of annual audits and a standard checklist, which could be interrogated and assessed by any potential charterer, and satisfied the need of charterers – to reduce auditing costs, but maintain an appearance of stringent risk assessment – and owners/operators – to reduce downtime and cost of repeated audits.

However, the downsides of this more structured process were manifold:

- More auditors were chasing less work, so prices and thoroughness were cut;
- The same auditor often performed the annual audit on successive occasions;
- The vessel's crew had less experience of observing single point failures;
- The annual audit became a routine task to be completed as quickly as possible.

This concern was regularly raised at industry gatherings and conferences, such as this one, where individuals discussed the need to improve standards and to ensure more rigorous verification and testing of DP system reliability. However, the bottom line was always "how much will it cost? and "why do you need more than one person? Each year on an annual DP trial, the auditor would challenge the relevance of the FMEA and recommend a revision or review, but next year nothing would have been done.

Although the influence of auditing initially (in the 1980s) rapidly reduced the number of DP incidents, particularly serious or fatal ones, it was found that very little ongoing improvement occurred after the annual audit was introduced. In fact, a series of incidents in 2002 (all in the UK sector of the North Sea) brought the matter to the attention of the UK's Health, Safety and Environment (HSE) Agency, who commissioned a study from DnV, suggesting that errors were not being designed out of the vessel systems by shipyards, contractors and suppliers.

The HSE/DNV "Review of Methods for Demonstrating Redundancy in Dynamic Positioning Systems for the Offshore Industry" confirmed this, concluding that vessel operators and managers are not always applying the guidance available and, in many cases, may not even be aware of it. It also stated that

> the perceived weaknesses in the FMEA technique are mainly as a result of:
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> - lack of application of adequate FMEA expertise;
> - not following a systematic procedure, i.e. weakness in the procedures for specifying, conducting and verifying the FMEA;

- being commissioned too late to influence design;
- not outlining all operating modes when specifying the FMEA.

2002 Incidents

Two of the three incidents that gave rise to the DNV-HSE Review are described below as typical of the type of failure in a DP Vessel's systems that can give rise to potentially dangerous conditions. In all three incidents (description of which is taken from the Review) there were no fatalities or injuries, but this was fortuitous and in worse weather conditions the outcome could have been more serious.

Incident 1

During routine saturation diving operations, with an ROV deployed, a DSV suffered a brief but complete loss of electrical power to all ship's systems, i.e. a blackout occurred.

All vessel systems that were powered from the vessel's power management system (PMS) were lost due to the power failure. Some systems that should have been protected by uninterruptible power supplies (UPSs) also failed. Control of the vessel was regained and all services were restored within 15 minutes, with all generators on line, all thrusters running and selected to DP.

The divers were successfully returned to the bells and recovered to the surface. The combined efforts of the ship's crew and the automatic functions of the PMS quickly and progressively restored power to the vessel's systems. During the period between the blackout and regaining control of the vessel, the vessel had moved some 190m from its original position at the work site.

The immediate causes of the incident were identified as technical in nature, although management system failures were also found to have contributed. The investigation found that there was a significant history of unexplained starting and stopping of machinery onboard the vessel going back over many years, although the significance of this history was not recognised either by offshore or onshore management.

In hindsight, it is clear that the previous events were significant in that they were indicating a fault condition that could, and ultimately did result in unsafe conditions. However, prior to the blackout and during the subsequent investigation, personnel operating the vessel believed that the FMEAs of the vessel's systems and the classification of the vessel confirmed that no single point failure could introduce unsafe conditions.

The investigation also uncovered that the FMEA was inadequate, but this had not been identified either internally or in the process of the many trials programmes and audits which the vessel has undergone since the FMEA was written in 1991. Because a blackout was believed to be impossible on the vessel, the crew had not trained to deal with such an event, no procedures were in place and no back-up power available.

Incident 2

During routine saturation diving conditions on a DSV, working inside a subsea jacket structure, the DP operators requested the engineers to start an additional bow thruster. The immediate consequences of this were a failure to start the bow thruster and stopping of the two stern azimuth thrusters. There was then a period of 10 to 15 minutes during which the vessel's operators and the power management system conflicted in their attempts to correct the situation and restart the thrusters, with a number of trips occurring.

After quarter of an hour the situation "stabilised" and the divers, who had abandoned their task immediately on receiving a Red Alert, were safely recovered, while the DSV had moved some 40 metres downwind.

The investigation found that a control system fault on the bow thruster starter had caused an over-current to occur, which as a result of inadequate system segregation had caused further control card failures to the azimuth thrusters. These faults had not been identified during the original FMEA, which had been regularly reviewed and was on its 5th revision at the time of the incident. Regular DP and FMEA trials had not identified the single point failure, which had not been considered possible.

Review Conclusions

The DNV-HSE Review concluded that the events they investigated involved rather complex faults – erroneous signals, a partial failure, a failure to relinquish control. Therefore, they agreed that the failure of the FMEA studies to anticipate them may be regarded as understandable. Nevertheless, they recommended that more specific guidance or checklists would be desirable to prompt consideration of such events in the future.

The subsequent investigations revealed actual deficiencies in the level of redundancy in the DP systems, which a thorough FMEA and trials programme should have detected. Thus the incident experience suggested to them that FMEAs or trials of DP systems were often not sufficiently thorough to ensure adequate redundancy.

DNV-HSE's main concern with the guidance available (specifically IMCA's 2002 document "Guidance on Failure Modes & Effects Analyses") was that it did not appear to be in widespread use. Some of the stakeholders questioned in their study were unaware of its existence or contents, even though it would be expected to support their work of conducting and reviewing FMEAs. Although some improvements to the IMCA guide were felt to be desirable, the Review thought it much more important to promote a management process in which guidance is actively sought and followed.

It was these conclusions and recommendations that led IMCA, on behalf of its offshore construction and maintenance industry members, to seek to develop high-level guidance in the form of the FMEA Management Guide.

Why Is The IMCA Guide Better Than Others?

Maybe it isn't, but perhaps the best way to explain what was intended is to quote from the FMEA Management Guide's introduction.

> Over the past ten years IMCA has produced a considerable number of guidance documents to assist members in commissioning and carrying out failure modes and effects analyses (FMEA) of dynamically positioned (DP) ships. More recently, IMCA has made available an on-line guide to the basics of DP systems on its website. However, there has not previously been a suitable guide to assist the decision makers and implementation professionals within the industry to assess quickly and easily the minimum requirements for carrying out an FMEA on a new

> vessel, and to assist them in ensuring that existing FMEA either already meet the standards or are reviewed and updated to the required level.
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> This FMEA management guide outlines the steps to be taken under different scenarios using flowsheets and then goes on to address the basic questions likely to be asked by managers and professionals. It directs them to the relevant industry guidance and standards necessary to achieve the high level of assurance against single point failures required by the offshore oil and gas industry.

In other words, the Guide does not seek to be another in a plethora of guidelines, as the initial research carried out found that most industry personnel complained of there being more than enough out there. What they needed to know was how to assess what their vessel had in terms of an FMEA, what they needed to do about it, and how to go about doing it? This information is particularly important for managers who have to prepare or approve budgets for FMEAs, as these are often extremely difficult to estimate and justify, and are very susceptible to cost-cutting exercises.

The first thing that was done in preparing the Guide was to hold a workshop (in Aberdeen) to allow as many stakeholder members to attend as possible. Although this was carried out at relatively short notice in 2003, there was a good turnout and many valuable observations and comments made. From this a draft outline was prepared and submitted to the IMCA Marine Division steering group, who supervised the development of the Guide. The final document was intended to be as concise and clear as possible, using flow charts to assist in the decision making process.

Application of the Guide

The realisation over the past few years that many current FMEA documents onboard DP vessels are either incomplete or obsolete has caused a different approach to be taken in carrying out FMEA audits or reviewing FMEAs. The IMCA FMEA Management Guide provides guidance on the specification of an FMEA, selecting practitioners, the carrying out of an FMEA (from the point of view of the manager and not the FMEA practitioner), verifying the adequacy of an FMEA and when an FMEA needs updating. It also lists various applicable standards and available documentation, and identifies who should read it.

With the assistance of major operators in the USA, the author’s company has applied a “Gap Analysis” technique, which is described in the Guide, to compare an FMEA against a checklist of standard systems and equipment. Gap analysis is a methodical investigation throughout the whole area of a given technology to identify ‘gaps’, thus highlighting those areas in existing technology that are inadequate and open to speculation, with a view to improvement, and thereby assists in the verification process.

At the conclusion of a gap analysis it should be apparent how well the FMEA relates to the vessel’s outfit and whether it accurately reflects the current systems as installed. This should form the basis of a work scope, identifying whether the FMEA needs updating and the extent of trials that could be necessary to clarify potential failure modes.

By applying this technique, particularly when carrying out post-incident investigations, it has been very helpful in identifying shortcomings in the knowledge and awareness of the DP operators and engineering staff onboard. This has highlighted where additional training is necessary to improve the capability and responsiveness of staff in the event that incidents do occur.

Earlier in this paper reference was made to the lack or inadequacy of management systems. These are often manifested in a lack of change control management, which is necessary if modifications, repairs or additions to the vessel's systems are to be identified and addressed by the FMEA. Although an update of the FMEA is not always required after every change, monitoring and recording of all changes will assist the operating company's management in assessing when the FMEA should be reviewed. The IMCA Guide gives an example of a control document that should be used to log any change to the ship.

The ISM procedures required these days should include the FMEA document and the change control recording, so that the company's management are always aware of the need to apply continuous attention to them. The FMEA document is not then just another report which can be found on the shelf in the wheelhouse.