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Risk, FMEA and Reliability

An FMEA Is For Life

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Abstract

There is a misunderstanding by many in the offshore marine industry that getting an FMEA done for a DP vessel is a potentially expensive chore that has to be gone through and (for example) that if you purchase a vessel which already has one then you meet all the demands of the Classification Societies and Regulatory Authorities and can therefore ignore it. In fact, this assumes that the only benefit of an FMEA is to meet the rules. This is like saying that your ship met Class when it left the shipyard and you don't have to worry about the documentation or surveys anymore. The fact that Class do not require FMEAs to be revisited every 5 years does not mean that this is neither desirable nor beneficial.

This paper will include examples of different types of DP vessel to show why continuous improvement and review of this documentation should be undertaken and why responsible ship managers need to budget for this. It will also propose ways to ensure that this is made easier through the incorporation of management processes and routines.

Introduction

Over the past years Wavespec has worked with many clients, ship owners, charterers and shipyards, to prepare and undertake FMEAs, and we have experienced many different attitudes when they request a quotation for an FMEA study. These have included quite different requirements, from looking for the cheapest way to meet Class, through being asked to participate in a design concept and feasibility study, to carrying out a full-blown FMEA over 2 to 3 years during a new vessel construction project. Although we now find that most clients are aware of the need to ensure that the study is carried out in a thorough and comprehensive manner, there is still a common misunderstanding among many operators as to which vessel systems need to be covered by an FMEA. The simple answer to this is that almost everything on the vessel could impact on the DP system, and therefore needs to be reviewed, however briefly, before it can be either incorporated or discounted.

However, some people in the offshore marine industry still seem to believe that getting an FMEA done for a DP vessel is a necessary chore that has to be gone through for Class, and that once done it can be put away and forgotten about. In fact, this assumes that the only benefit of an FMEA is to meet the rules. This is like saying that your ship met Class when it left the shipyard and you don't have to worry about the documentation or surveys anymore. The fact that Class do not require FMEAs to be revisited between the 5 year special surveys does not mean that a ship owner or operator should not consider the value of keeping this document relevant and current. Hopefully, this paper will persuade the reader of the benefits of this approach.

An FMEA (or Failure Modes and Effects Analysis) is a process that is undertaken in order to prepare a document called an FMEA Report. Such a document is required by the major Classification Societies in order for them to grant a vessel a certificate for either a DP Class 2 or DP Class 3 notation. For DP2 this means any vessel which is classed as being able to maintain a fixed position relative to either the seabed or another vessel or structure while experiencing a single system fault in any active component or system. For DP3 it requires normally static components to be included in the analysis, including the loss of a single compartment. A DP vessel which cannot meet this requirement, i.e. one which is not designed and built with the redundancy to resist such a failure or fault, will be classed either DP Class 0 or DP Class 1 and does not require an FMEA Report.

We have noticed a tendency in recent years for some ship owners to look for an FMEA even for a DP Class 1 vessel. This is commendable as it helps the operators to better understand their vessels and what could happen as a result of a failure. However, it should be understood that an FMEA done for a DP1 vessel will not be sufficient if the vessel is subsequently upgraded to DP2 or DP3, although the failures highlighted by a thorough FMEA will assist the operator in identifying the systems that will need

changing. In these circumstances the FMEA itself will also need to be upgraded to reflect the higher Class notation.

In the past Class has not spelled out clearly what they require to be analysed in an FMEA, i.e. all systems and subsystems having an effect on station keeping, so we find that some owners have submitted DP FMEA Reports that only include the DP control system. As these are usually done by the DP system manufacturer they impose no additional cost to the shipyard or ship owner. However, they are worthless in meeting the goals of an FMEA!

A positive move over the past 12 months is that the major Class societies have issued their updated Class Rules for 2008. They have significantly strengthened their requirements for FMEA documentation by expanding on the scope of vessel systems which must be included in the FMEA study. This is a significant development because, as stated above, we find potential clients who believe that an FMEA issued by the DP system manufacturer is all that is required by Class. We have seen cases where this is all that has been submitted to the society with the application for notation, and in the past notations have been issued on this basis. It is certainly not before time that this further misconception is put right, and the scope of work of the FMEA practitioner is therefore likely to be better understood.

By way of an example, Lloyd's Register's July 2008 Rules expand upon the scope of an FMEA for a DP Class 2 or 3 vessel by adding that "Systems that are not part of the DP system but which, in the event of a fault, could affect the correct functioning of the DP system (for example, fire suppression systems, shutdown systems, etc.) are to be included in the FMEA". Other Class societies are not so specific, but overall they are all clarifying what has, until recently, been a somewhat grey area to many people.

What is Meant by a "Proper FMEA"?

This is a phrase that is often used by people in the industry to specify what they want, without it always being clear what they mean. The usual definition for the contents of a "proper FMEA" is to refer to the IMCA guidance documents, although the practical interpretation is often found to be what the Class surveyor will accept. Some major operators or charterers of DP vessels also have their own requirements that can exceed both guidance and rules. However, we have found that this is one of the more difficult aspects of undertaking an FMEA for a client. The tightening up and clarification of the Class Rules should help to ensure that the worldwide standard and understanding of what is "proper" becomes more consistent in the industry, and help newcomers to the DP marketplace in meeting the high standard that is required.

In the past we have encountered some criticism and anti-FMEA feeling from various people over the amount of analysis, drawing review and data gathering that has to be done, often from the crew of the vessel, whose attitude was that we were just a nuisance value and holding up the day to day running of the vessel. What we were in fact doing was taking them out of their "comfort zone" and they had to start thinking outside of the box. We have always found that when they and their shore management eventually realise what we are trying to do they usually buy into the process and find that it increases their knowledge of their particular vessel. In operational terms this can only be good for faultfinding and reducing downtime. However, even if the ship's crew recognise this, it is not always supported from the office management!

Regarding the amount of data gathering and analysis, our view is that if the analysis of a sub system is not recorded in the FMEA report (in the form of system descriptions, reliability block diagrams, worksheets, and a Q&A punchlist) then there is a question with regard to failure modes and the system's response to them. An FMEA that does not explain how each system has been analysed, which questions have been answered and clarified, and which does not present the workings of the analysis, cannot be assumed to have considered those systems. When it comes to reviewing that FMEA in future, either at an annual DP trial or during a Gap Analysis, it is likely to mean that the system analysis has to be repeated. This will

increase the cost of subsequent reviews and audits, as well as taking additional time before a vessel's capability and suitability for DP operations can be assessed.

Another crucial part of a "proper FMEA" is the carrying out of FMEA trials. Apart from being the only way that some of the potential consequences of failure can be assessed, this could be the only time the crew witness major failures in the vessel's systems (albeit controlled failures) and they can learn from them without causing any damage or expensive downtime. So the FMEA trials are a good and vital training tool and can be educational for new and existing crew alike. If the trials results are well documented, and a problem occurs later with the DP systems that the operators are unsure of, they can be referred to as a source of possible answers.

In fact, the whole FMEA process is a good training tool for the ship operator, as the questions that arise from the process make the technicians and operators find out more about the systems on the vessel than the day to day operational tasks would ever do. If all the guidance steps and processes are followed and completed, the resulting FMEA Report should ensure that the client receives a "proper FMEA" that will serve as a good basis for the life of the vessel.

How To Ensure Getting Value for Money

If your only purpose in commissioning an FMEA is to get a DP Class notation and certificate then you may wish to explore the cheapest possible way to get one and then forget about it – assuming that the Class Society accept it as adequate. However, we and many others in this industry believe that there are other valuable benefits of a quality FMEA that mean that a thorough study and comprehensive document is a good investment for the future operation of the vessel, as well as ensuring its maximum residual asset value. These benefits include:

- A thorough, up to date FMEA protects the owner's assets, protects the charterer's interests and reduces project risk.
- An up-to-date FMEA can reduce vessel downtime as it can simplify the problem solving process. A thorough FMEA, covering all eventualities, has the potential to prevent or, at a minimum, shorten downtime.
- As the FMEA trials could often be the only time the crew witness major failures in the vessel's systems, the FMEA trials are a good training tool.
- One major benefit of an FMEA is when it forms part of the design phase of either a newbuild or modification process. It can be very costly if a single point failure analysis is not carried out at this time. Our experience is that it is much easier to change a construction drawing than it is to change a pipe run or cable run.
- A Gap Analysis of an existing FMEA can help to identify the potential costs for upgrading the DP Class of a vessel, by highlighting those areas that will need upgrading.
- Maintaining an up-to-date FMEA avoids the need for a future expensive re-analysis of the vessel systems and rewriting of the report.

An FMEA has to be done using "as built" documentation and in the case of an existing vessel this could have changed. There is hardly a vessel out there that has not had some modifications carried out on it, authorised and/or unauthorised. We have uncovered such modifications which could have had a massive impact on the station keeping of the vessel were a failure to occur. A recent typical example, during an upgrade project, was where a system drawing showed the main and backup thruster controllers to be powered independently from separate UPS units, i.e. main controller supplied from one UPS and the backup from the other. Close inspection showed that diodes had been used to supply the main and backup controllers from both UPS units. A fault on the common line would have lost all thrusters. Even the crew were unaware of this modification. The question to ask is "Would a less rigorous FMEA have picked up this design weakness?"

When modifications are carried out, it is very often only with “Let’s get it to work” in mind. This is not enough, it should be with “Let’s make it work in normal operation and ensure that it fails safe in any failed condition”. This is what the FMEA process does, and updating the FMEA should be an integral part of carrying out any modification.

There is No Shortcut to a Quality FMEA

As mentioned in the introduction, there is a view that if you purchase a vessel which already has an FMEA then you have met the demands of the Classification Societies and Regulatory Authorities and can therefore forget about it. This depends entirely on the quality of the FMEA Report inherited with the vessel, which should accurately describe and represent the systems presently installed on the ship. If it does not, and has not been kept up-to-date, the prospective buyer could be misled into thinking the vessel has a higher DP capability than is the case in reality. There is rarely a bargain when buying a good DP vessel and, as in any other walk of life, if something seems too good to be true it probably is!

For example, one of the present trends in the offshore vessel market is to buy a secondhand DP Class 1 vessel and upgrade it to DP Class 2. This is done partly because there is a call from charterers to hire a Class 2 vessel because they appreciate the additional safety and operational flexibility that this brings, and partly because there are a considerable number of Class 1 vessels available as ship owners trade up to new vessels. However, we have encountered a common misconception that the only addition that will be required is to the DP Control system, including perhaps additional position measuring systems and a third gyrocompass. In fact, the most significant differences between a Class 1 and Class 2 offshore vessel are likely to be in the machinery piping systems and electrical distribution systems. These are often not considered when a potential ship purchase is being considered, although the fundamental redesign of engine room and machinery systems could be expensive to change and upgrade, and needs to be included in the cost analysis and budgeted in the conversion.

Another critical system encountered in such vessels is the thruster arrangement, in particular whether a single stern thruster can be considered as sufficient if one or more high lift rudders is included in the main propulsion system. This has in the past been an area for conjecture or sometimes negotiation, but clearer guidance is now available. For example, DNV’s January 2008 Rules state that “A position keeping ability shall be maintained without disruption upon any single failure. Full stop of thrusters and subsequent start-up of available thrusters is not considered an acceptable disruption”. This would prevent the option of a single stern thruster supplied from either side of a split main switchboard being accepted as a solution to a partial blackout fault.

Similarly, when considering the capability of a main engine and high lift rudder to replace the transverse thrust from a failed stern thruster, DNV makes it clear that “Component and system redundancy, in technical design and physical arrangement, should in principle be immediately available with the capacity required for the DP system to safely terminate the work in progress” and refers to the capability plots and consequence analysis as determining this capacity. In reality, a vessel upgraded from Class 1 to Class 2 with such an arrangement will have very limited environmental capability if it is to meet these criteria.

As mentioned above, Class Societies are becoming much more focussed and careful in assessing the capability of vessels to meet their Class 2 and Class 3 DP notations. The 2008 Rule changes have tightened up significantly on the interpretation of meaning which has resulted in less leeway being granted to local and regional surveyors. We have already experienced one occasion of this where a local surveyor had appeared to give a favourable interpretation for an upgrade modification to Class 2, only for his head office to refuse issue of the certificate of notation. Although this was not welcomed by the ship owner concerned, it means that there is likely to be more consistency in future, which can only be good for the industry in assessing the standards required.

If an owner purchases a vessel that has an FMEA, it would be prudent for him to have a “Gap Analysis” carried out by independent assessors to ensure that the FMEA is comprehensive and up to date. Such an

analysis is relatively cheap and can give additional assurance and comfort to an owner or operator that the vessel meets its intended standard of DP performance. It should also highlight the areas of any existing FMEA that need to be updated and reviewed.

When is an FMEA Incorrect?

Conventional practice with ship classification is that certification and inspection runs on a 5 year cycle. These periods are called Special Surveys and normally every part of a vessel is inspected during a special survey period. This also applies to the certification associated with a DP Class notation. However, a modification to an offshore vessel can occur at any time and it is not necessarily sensible or good practice to wait for the next Class survey to occur before reviewing and updating the FMEA. The annual DP audit is an opportunity for the surveyor or auditor to check whether the FMEA onboard really does reflect the actual vessel systems. He or she should ask the relevant questions of the vessel operator to ensure that potential single point or hidden failures have not been introduced by upgrades to the ship and, if any doubts exist, report that a review and/or update needs to be undertaken.

Whilst updated Class rules are not retrospective for a ship unless it undergoes a major upgrade, whenever any modifications are undertaken the FMEA will become out of date. For a major upgrade, a new or updated FMEA will be required and the FMEA Report can help with ensuring that the latest Class rules are met.

The IMCA guidance document M178 states that the FMEA will become out of date if it is not maintained regularly and systematically, due to changes in operating procedures, modifications to DP hardware and software, etc., over the life cycle of the vessel. Review of the FMEA must be an ongoing process throughout the life of the vessel, and use of the ISM system is the best way to ensure this occurs. A failure to maintain the FMEA would then constitute a breach of the ISM code. Verification of the FMEA's current relevance to the vessel should be guaranteed by adopting this process.

Company procedures must be put in place for document changes (e.g. in compliance with ISM Code procedures), including a change control management procedure to aid traceability and accountability of FMEA system updates. Adopting a change order process within the ship manager's ISM system should also assist in identifying where modifications have been made that could affect the integrity of the DP class status, i.e. where they could introduce single point failures. Such a process is common in many companies and should include the DP systems within it, so that regular audits and checks are carried out of the FMEA documentation.

It may not be necessary to update the FMEA formally on a regular basis, provided that any changes that are made during the life cycle of the vessel are properly recorded and analysed. It is suggested that a regular basis for verifying the FMEA, to ensure that as described in IMCA guidance document M178 it is still representative of the systems on board, would be in the order of 12 months to 24 months. The effectiveness of the FMEA verification process should be determined by a vessel management company internal assessment. The FMEA itself should contain references to any changes which have affected the FMEA since its original version.

Conclusions

The objective of writing this paper has been to make it clear to the operators and owners of DP vessels that commissioning an independent or third party FMEA of their vessel can be a constructive activity that will bring benefits to the vessel, not just a means to meet the Class rules. Although an FMEA is now recognised as a fundamental requirement by Class, the advantages of a thorough and up-to-date FMEA document are many and the most important aspect is that it should be put right at the forefront of the company's DP requirements for their vessel. This means that the FMEA documentation should be considered first and foremost when designing and installing a DP system in a vessel. In order to ensure

that it is maintained, continually accessed and used by the ship's crew, it needs to be included in the ISM system for the vessel and regularly reviewed and updated throughout the life of the vessel.

The opinions and proposals expressed above are equally valid for every type of DP vessel, from anchor handlers and platform support vessels to the latest deepwater drilling rigs and new concepts for floating offshore production and storage platforms. The examples quoted in this paper are taken from a number of recent studies that we have undertaken and that we know are common to the industry at all levels of technical sophistication and in all regions of the world.

The development of the FMEA process has been an evolutionary one over the past 20 or 30 years and has been based on long experience from many people, which has led to the present processes and guidance. As in many other industries, particularly in the oil and gas business but also in the automotive and aerospace sectors, industry liaison groups such as MTS have led and actively participated in the improvements that have been made since the early days. It is always the best solution for an industry when it puts its own guidance in place, as opposed to awaiting prescriptive legislation from others. The offshore industry has been successful in this way and we believe that a correct use and application of good FMEA practice and guidance should ensure that incidents of position keeping loss are kept to a minimum and the overall standard of DP vessel system design is continually improved.