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VERIFICATION, TESTING AND TRIALS

**Practical Issues Concerning the
Conduct of an FMEA on an Offshore Vessel**

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Introduction

A considerable amount of time has been devoted to the mechanisms of preparing a Failure Mode and Effect Analysis. International standards have been considered and compared, the methodologies of the processes have been reviewed, and presentation and structure critiqued, yet surprisingly little time has been set-aside until now to consider the practical aspects of the FMEA proving trials themselves. It is hoped that with this short paper, combined with some of the other contributions in this session, this omission may be remedied and the subject brought a little closer to the sunlight since, although it only represents a very small part of the whole of a project, its ramifications can be extensive.

The C-MAR Group have completed a number of Failure Mode and Effect Analyses on Dynamically Positioned vessels both in the Gulf of Mexico region and worldwide.. The types of vessel involved have varied greatly from Platform Service Vessels through Diving Support Vessels to Semi-Submersible Drilling Rigs. Similarly the age and type of installation has also varied from new builds, to upgrades and conversions. This has given our Auditors and Consultants a considerable body of experience to enable them to judge how a particular FMEA audit can be approached and what to expect under differing situations.

The complete set of criteria which follow are based upon those experiences. It should be noted however that they represent the ideal requirements for conducting a trials programme and that it is rare that the ideal is encountered in practice.

Preparation of the Trials Programme

The FMEA for Dynamically Positioned vessels attempts to examine the critical components involved in giving the vessel the ability to maintain station and to quantify the effect of the worst case failures of these components on that ability. The failure level that the FMEA considers is defined by the International Maritime Organisation and the various Classification Societies is that of a Single Point Failure. Broadly speaking, that is to say that no one fault in any system can result in the loss of vessel's ability to maintain position under DP. This limitation considerably simplifies the extent of the work that needs to be done by the FMEA team since multiple failures, in other words the 'domino effect' need not be taken into account.

Obviously, a large number of sub-systems are involved in the analysis, and the greater the complexity of a vessel the larger the number of these sub-systems. Dependent upon the level of interactivity and the complexity of these systems the FMEA may deal with their internal failure modes on a unit or component level basis. It is the aim of the FMEA trials programme to verify the conclusions drawn by the analysis and at the level considered by the analysis.

This is an important point to understand. Since the trials programme is based upon the FMEA, it is therefore the prime purpose of the Trials themselves to prove the redundancy of the vessel system design and not intended to uncover deficiencies in it. This is an issue that will be considered later. Furthermore, since the Trials Programme should be based upon the FMEA, it follows that the trials procedures should be written concurrently with the preparation of the FMEA.

It is regrettable, but true, that in some instances the FMEA is considered as an item of regulatory red tape hoisted on the project design team by the Classification Society which need only be

considered at the last moment and a negative view of the Trials Auditors, or even the FMEA Team, is sometimes encountered as a result.

In such cases the FMEA Team and the Trials Audit Team are often one and the same and attempting to produce the FMEA and the Trials Programme simultaneously and at the last moment. Where this occurs it is often difficult to gain access to all the materials necessary to complete the audit and the FMEA process.

In these instances it is not unknown for the FMEA process to uncover major single point failures, which are inherent in the design of a vessel. Rectification of such design flaws at this stage can be, and often are proved to be, costly and time consuming, and can severely impact on project completion and delivery. Naturally in these instances that negative image of the FMEA Auditors is likely to become reinforced and for this reason the arrival of the FMEA Auditor is so often met with the same form of warm and cordial greeting as that usually reserved for the Internal Revenue.

It has been our experience that trials procedures, hurriedly written on the eve of the trials themselves often fall far short of ideal. In addition, adequate co-ordination during the trials period is rarely achieved under these circumstances.

There is an argument that a separate party than that which is producing the FMEA should compile the Trials Procedures. However, it can be understood that the approach required would probably lead to a duplication of effort, in effect a second FMEA, and it is up to the Project Management to decide if this approach is financially viable.

The sequence that the tests in Trials Programme itself should be performed should be tailored as best as possible to dovetail into each other. Tests, which involve the same or similar equipment taking place consecutively. This makes the maximum use of available personnel and those who are needed for some other duty may be released. In addition this approach helps to minimise offline time of critical vessel equipment such as cooling water pumps, ballast systems, drilling or diving auxiliary equipment etc.

Pre-Trial Preparation

All persons involved in the programme should be familiar with the FMEA. Where the FMEA is presented in an easily understandable form, particularly when it exists as a stand-alone document, a familiarity with its contents leads to a greater understanding of the operational characteristics and capabilities of a vessel. A considerable amount of time can be saved where all parties understand the aims of the FMEA document and their roles in the programme explained.

A copy of the FMEA and the Trials Programme should therefore be issued to the vessel's crew sufficiently in advance of the Trials for them to study the document and prepare themselves to carry out those sections of the procedures, which require their co-operation. This practise has been found to be useful since it both familiarises the crew with some of the major operational aspects of the vessel and also gives them the occasion to critique the FMEA. Occasions have arisen where the crew are privy to field modifications, which have not promulgated to the project management and hence to the FMEA Team, at such times this knowledge can affect the course of the trials by removing or modifying procedures, which would otherwise produce erroneous results.

The FMEA Trials Auditors should discuss the FMEA and the trials with both Project Management and the vessel crew in order to fully familiarise them with the aims of the programme, in this way false or erroneous conclusions may be avoided which could otherwise lead to an incident similar to that described below.

At this point it should be emphasised that it is important that the crew fully understand the aims of the FMEA especially as it applies to normal operational practice.

On one occasion the ship's crew were aware that a construction modification, which had been completed without the knowledge of the FMEA team, would affect the outcome of a test involving the steering gear pumps. When the test was about to be performed a crewmember was stationed so as to be able to manually re-assign and start the stand-by pumps. Fortunately, the Auditor recognised that an attempt to falsify the outcome of the test was taking place and the test was finally completed correctly.

This type of action highlights the need for a vessel's operational staff to understand the basic principles behind the principle of the FMEA. In addition it highlights the attitude mentioned earlier that the Auditor is sometimes seen in a negative light, and that the discovery of any non-conformity during an audit may result in disciplinary action.

Some of the most important elements in the success of any project are often considered to be planning, co-ordination and information flow. It can be seen from the previous comments that the preparation of the FMEA Trials programme is no exception.

The Audit Team

The make-up of the trials Team should also be carefully considered on a case-by-case basis.

The size and complement of the Trials Audit Team obviously varies between vessel types and complexity. Our teams have varied between one and five in number. It is usual to appoint one member of the team as Trials Co-ordinator. The responsibilities of the Co-ordinator include liaison between Project Management and the Audit Team, and co-ordination of the vessel staff, vendor's representatives and to ensure preparedness of appropriate systems in order that the trials may proceed in an orderly and timely manner. It is worth noting here that the Co-ordinator need not be a member of the Audit Team. It has been our experience that relations between Project Management and the Audit Team have been considerably easier when the Co-ordinator was, in fact, a member of the Project Engineering Team.

Obviously a team of this size is only needed when the vessel being audited is an especially large and complicated one, such as a DP Drilling Rig for example. In such instances the number of tests in the programme can be significant and take several days to complete, especially in those instances where the vessel's state of preparedness is not ideal. Because of the duration of the trials one team cannot be expected to operate continuously and it has been necessary to run two teams of Auditors in order to achieve twenty-four hour coverage. Smaller vessels where less extensive automation and control systems are installed consequently require a smaller audit team and one person, when adequately assisted by the vessel's crew, can complete the trials period alone.

State of Readiness

The vessel should be ready for the FMEA Trials to begin.

This may seem obvious, but we have been requested to mobilise an audit team to more than one vessel only to find, when the team members arrive on site, that the vessel is still in the commissioning process or, even worse, in the middle of construction with half the major equipment lying on the quayside waiting to be installed.

Limitations

The conduct of an FMEA on board ship is normally limited by two main factors: commercial and operational. The major commercial issue being that the vessel is out of operation during the conduct of the trials and hence off contract. The Owner or Contractor obviously wants the vessel to commence or return to operation as soon as possible in order to return to a revenue earning status. The operational constraint usually affects the range of reference sensors available for trial. Although the commercial conditions may make for difficulties during the trial period the long-term effects of the environmental and mechanical limitations may adversely affect the vessel during operation. In this respect three specific systems come to mind:

- Artemis
- Fan-Beam
- Electric Riser Angle

Each of these systems requires a specific operational environment to exist before their operational capability and associated failure mechanisms can be fully assessed. All of them require a fixed structure of some sort to be in place. One requires that electric power be available on the structure.

Testing of any system where the co-operation of a third party is involved has a dramatic effect on the costs of the trials themselves since a number of logistic elements must be taken into account, these include transportation of the equipment to the site, installation, setting up and demobilisation.

Testing of both Artemis and Fan-Beam require that the test take place at a location relatively close to the fixed structure and the ERA requires that the BOP Stack be deployed.

The very nature of the FMEA trials places the vessel in a position where, potentially at least, loss of DP control may occur and hence it is not without reason that a platform operator might act with some degree of prudence when approached to lend an offshore structure to an enterprise of this nature.

Similarly, an incident involving a deployed BOP stack would have a considerable impact on the vessel and a full function test involving this equipment is also unlikely to be sanctioned.

These conditions, while regrettable, are understandable, however it should be borne in mind that DP incidents have occurred involving communication signal failure with at least two of these systems.

Annual Trials

Annual FMEA audit trials are generally a much simpler affair than those combined with the initial vessel proving trials and can, when properly co-ordinated and arranged be completed in a 24 timeframe. Here again, however, a degree of planning combined with adequate information exchange can considerably improve the conduct of the audit.

It has been our experience that when the Auditors are familiar, to some degree, with the vessel, its FMEA and the initial proving trial programme, the annual audit trials proceeds in an efficient manner. Here again the original FMEA plays an important part. Many FMEAs are not 'stand-alone' documents and can only be understood when referenced to the vessel system schematics. In circumstances where time is pressing the Auditor may be tempted to rely entirely on previous test results without reference to any system schematics. An audit under these circumstances merely repeats the results of earlier tests; it does not verify their conclusions. This circumstance is less likely when the FMEA document contains outline schematics or illustrations of the systems under test. When the audit is undertaken with reference to the system schematics then it is more likely that the Auditor and all other personnel involved in the test programme have a greater appreciation of the purpose of the procedures and their relevance to the FMEA and Class compliance.

In addition, the Auditor can also verify that the vessel is being operated in a manner, which is in accordance with the circumstances for which the FMEA is applicable. In one instance one of our Auditors arrived on a vessel where the FMEA document had not been issued to the crew and found that the main switchboard was not configured in a satisfactory manner. Interviewing the crew, he found that their understanding of the principles of Class requirement were somewhat patchy and that the switchboard had been configured in a manner based upon false assumptions and was thus set up so that a complete blackout was risked in the event of certain failure conditions.

Summary

In summary, the essential ingredients to ensure a successful conclusion to any offshore audit, no matter what the size or complexity of the vessel, are:

- A full understanding of the intent and meaning of the Class Rules on the part of all parties concerned.
- Familiarity with the vessel systems on the part of the Auditors
- Familiarity of the FMEA and the FMEA trials procedures on the part of all parties involved in the test and the test programme.
- Adequate planning and
- Strong, centralised co-ordination

Three major constraints can be seen to limit or constrain the complete effectiveness of the FMEA proving trials: the time available for completion, the availability of position reference sensors and the state of readiness of the vessel.

Sufficient time to complete the trials must be made available. Nonetheless, this should not be read as giving the Auditor carte blanche, the Auditor should bear in mind the economic consequences of unnecessary delay.

With regard to reference sensor availability, the audit will remain limited to the available equipment. It is not practical, except in certain extreme circumstances, to expect testing to take place on certain systems. In these instances, the audit must fall back upon theoretical assumptions and the results of factory acceptance testing and any offline tests, which might be possible.

The state of readiness of the vessel is the final limiting factor; If the vessel is still in the final stages of construction or commissioning, it would be wiser to postpone the commencement of the FMEA trials programme until all equipment has been tested and determined to be satisfactory by the vendors and owners. In the case of operational vessels, when significant portions of the DP system, this includes power and generation plant, are in a degraded state, then the audit should not proceed.

An audit should be neither positive nor negative in direction but should present the circumstances found in an objective manner. Where the majority of the equipment can be tested and the programme proceeded in an efficient and timely manner the best possible audit outcome will result. The audit reflects the conditions observed on board the vessel. Practical testing is limited by circumstance. Auditors and Management should both bear these points in mind.