Session Index

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APPLICATIONS

Collection of DP Vessel Disconnect Data

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Overview

As operators go into deeper and deeper water there are a number of risk inherent when operating DP drilling and completion vessels. Through a simple review process it is possible to identify these hazards, and quantify the risks. As part of a study for one major operator in the Gulf of Mexico quantified risk assessments (QRA) were undertaken for drilling and completion activities. During the study, the level of the risk was very much dependent upon the quality of the data. This highlighted the fact that the data that is available for such exercises is sparse and synthesis of other data and engineering judgement had to be undertaken to ensure meaningful results. The following paper will describe in some detail the methodology used to assess deepwater DP drilling and completion risks and the reasons outlined for the proposed suggestion that a database of disconnect events should be established.

DP Drilling and Completion Operations Risks

If a DP drilling vessel exceeds a specific operating “watch circle” radius then the operation will have to be suspended. In terms of vessel watch circle, this trigger point is based on Flex Joint angle commonly known as (FJ1) or “Degraded” status.

If the vessel’s loss of station keeping continues to deteriorate then the operation will have to be suspended by “hanging off” the pipe in the BOP rams. This trigger point is sometimes known as FJ2, or “Yellow Alert” status. If the vessel recovers from this point the costs are generally minimal.

If the situation continues to deteriorate further i.e. the vessel continues to move further off station that is it exceed FJ3 “Red Alert”, then the only solution to the problem will be to secure the well (Close the BOP Blind Rams) and disconnect the vessel from the well. If at this time there is a tool joint or drill collar across the BOP stack the ability to disconnect cleanly is severely jeopardised. In some cases e.g. a powered “drive off” the time from exceeding the operating watch circle and the requirement to disconnect can be very short (< 60 seconds). Therefore there is the potential for serious damage and even the possibility of a hydrocarbon spill if everything does not work correctly. The general view of the DP industry is that the average cost of a single disconnect incident is around $2 to $3 million. This figure could be even larger if a hydrocarbon spill were to result, although the risk analysis indicated that this possibility is an extremely low frequency event.

As can be seen from the very simplistic description shown above, this series of steps (including the disconnect sequence) can be described very simplistically as a series of gates with a “success or failure” point at each gate. By the use of the risk analysis technique know as “event trees” it is possible to both diagrammatically represent the decision points and assign a probability of success or failure to each gate. The use of the event tree technique describes and enables quantification of the sequence of all event outcomes given a single initiating event. In the case of DP drilling vessels this single event is loss of station. To enable the calculation of the event trees data on DP vessel loss of station is required. A simple event tree is shown in Fig 1.0.

Multiplying the event tree end event frequencies with their associated consequence values identified in terms of dollars, a “risk cost” can be calculated. When the individual end event risk costs are summed for a particular operation, the “loss of station” risk cost of the total operation can be calculated. Using this technique the average cost of $2 to $3 million dollars per disconnect event was calculated. It should be noted though that this cost is based upon a number of factors and assumptions specific to the individual study. When this cost is averaged over a 5 year drilling contract with an expected frequency of one (1) disconnect every five (5) years the daily cost is only around $1100 dollars.

From this Quantified Risk Analysis (QRA) the major causes contributing to the higher risk associated with DP operations are as follows:

- The largest contributor to risk cost figures was identified as the failure to maintain station.

- The study indicated that this frequency was one of the areas of the greatest uncertainty because of the lack of good quality data associated with DP drilling vessels available to the study.

- Failure to secure the well during an emergency disconnect situation (failure of the shear rams to close and seal, failure of the LMRP/LWRP connector to open) was identified as the second largest cause contributing to risk. The reason for this statement is the actual potential for well flow. The study estimated that the expected frequency of these events was extremely low and their risk costs are included in the $2 to $3 million dollar cost per disconnect.

Given this background information the results are heavily dependent upon the data used in the model. To account for some of this variability the analysis used a triangular distribution for the cost side of the risk equation. There was no such variability used for the frequency side as this was based upon data from the data banks available to the offshore industry. These databanks are briefly described below.

Addressing the Problems of Risk Analysis and Data

The caveat's regarding DP drilling "loss of station" data would seem to indicate that the overall results could be treated with a degree of scepticism. With better quality data the estimates can be refined. To overcome the problems with data the following comments can be applied.

The risk analysis was not designed to provide an absolute figure, but to provide a tool for comparative purposes.

The use of risk analysis for comparison of alternatives is one of the strong points of QRA.

QRA allows confidence to be placed on the data to enable a range of risk values to be calculated.

The data can be reviewed and ranked to ensure consistency, but these figures can be refined with better quality data.

DP Data Availability

In the DP industry today there are already some reliability databases and in-house company records that have been used for the analysis of risks involved in the deepwater DP drilling and completion operations. These include the following

- Individual DP drilling companies records. The operators of DP drilling vessels will maintain a record of DP systems failures which resulted in a disconnect for the each fleet of vessels. These records are specific to the fleet of drilling vessels operating to day and are the property of the drilling contractor. Though the operators can review these records and contractors are willing to provide their individual records to the operators at the bid evaluation stage of contracts.

- DNV's Worldwide Offshore Accident Databank (WOAD) has several DP incidents included in its archive. These due to the limited number are of little value when addressing the failure of DP drilling vessels.

- The Sintef organization published a report on the reliability of subsea blowout preventers (BOP) in 1987 and again in 1992. These records were obtained from drilling contractor records. This data does not reflect the latest data on deepwater BOP system which will be used on the latest generation of DP vessels. It is therefore considered that the data from this source needs to be updated to reflect the latest generation of BOPs.

- The Offshore Reliability Data (OREDA) handbook and software contains reliability data of mainly topside equipment. Although the OREDA handbook does not cover DP vessels it does allow the synthesis of systems reliability figures using the individual components such as diesel generators, and can be useful in modelling the reliability of DP systems

- DP Loss of Station Keeping data from the North Sea. This database is collected and analysed under the auspices of the DPVOA/IMCA. It provides a record of the failures of non-drilling vessels in the North Sea. The database has several possible flaws which make it’s relevance to the deepwater DP drilling industry suspect. These possible flaws are;

    - The DP data is generally of platform support type vessels. These vessels operate in a different DP mode compared to deepwater drilling vessels. Therefore if this data is to be used, assumptions have to be made on how the figures are adjusted for the deepwater DP drilling vessels.

    - The Mean Time to Failure (MTTF) of these types of DP vessel is not calculated and assumptions and engineering judgement have to be used to estimate the MTBF.

- In addition the DPVOA/IMCA has also produced a series of individual reports on different aspects of DP vessel systems. Mostly these are qualitative in nature but do provide useful reference points for the systems they cover.

From a review of the data sources the best and most applicable is the DP drilling contractor data. This data will include disconnect records of individual vessels from when they started operating and therefore should include a number of disconnect incidents. This data though is not available to the industry as a whole and therefore the proposal here is to collect available data and analyse it. The purpose of the data collection and analysis is to provide a forum to encourage the DP deepwater drilling community to be open with regards to DP system failures. This openness should be along the same lines as the offshore industry’s reporting of Lost Time Incidents (LTI’s) which are reported and analysed for lessons to be learnt. First though a short discussion on the different types of data and which should be collected and analysed.

Statistical Failure Data

Although the above sources provide good statistical data on equipment and sometimes components there should be a word of caution expressed about the use of such databases. Failure data of equipment or components is largely derived from statistical analysis of past data. For such exercises a large amount of data is required to derive an accurate statistical relationship. For example, the true value of a life parameter is never known, only it’s distribution about an expected value, so we cannot say when failure will occur. Sometimes we can say that the likelihood is increasing e.g. if wear is detected in a bearing, but we can very rarely predict the time of failure.

Therefore it is never sensible to make a prediction based upon past data unless we are sure that the underlying conditions which can affect future behaviour will not change. It may be that the predicted figures could be either pessimistic or optimistic. Therefore in the analysis of DP systems it is important to note any errors where data may have been used out of context and these should be adequately explained. A common error in the design of systems is the use of individual parts reliability figures which when combined together provides a reasonably accurate prediction of the system. These individual parts or component failure rate are then used to predict the sparing requirements, and make decisions regarding safety. It should be noted that the variance of the reliability of components could be orders of magnitude greater than the variance of the system level figures. Therefore the prediction of reliability of systems based upon the use of mathematical models and standard data should be treated with caution and not a substitute for good engineering and operational experience. Reliability data can be useful in specific prediction applications, such as petrochemical plants or offshore when the data is derived from the area of application. However, such data should not be transferred from one application to another area without careful assessment. Even within the areas of the data's application, it should be used with care, since even then conditions can vary widely.

How therefore has DP Vessel Reliability Been Achieved?

Outlined above there has been a discussion of the usefulness of using reliability data and the actual data that is available to the deepwater drilling industry. It should be noted though that although there is data available for use by the deepwater drilling industry it's use has been limited to particular aspects of a design. Therefore how has the reliability of DP vessels been achieved?

The reliability of any equipment or system is based upon several sound engineering principals, such as

- Quality of the Design.
- Quality of the Equipment Purchased.
- System Configuration such as redundancy and reliability engineering
- Maintenance of the System.

Taking each of these areas the following general comments can be made.

In any design the performance of the system can be affected by the quality of the design incorporated from an early stage. This includes the factors such as the use of Failure Modes and Effect Analysis (FMEA), Corrective Action Reporting (CARF) and Test Analyse and Fix (TAF) procedures. A classical example is the known reliability of Japanese Automobiles where quality control is considered one of the highest priorities. In the case of DP drilling vessel where the design is of a bespoke nature the quality of the build is very much dependent upon the quality systems employed both by the design contractor and the vessel build contractor.

The quality of the equipment purchased has a strong influence on the reliability of the system. There is the old adage "that you only get what you pay for". This is very true in terms of reliability. Obviously in the purchase of a DP vessel there are certain known contractors who will supply equipment for systems and their reliability can be assured from the industry's operating experience. In other areas though the supply of ancillary equipment to the system from unknown vendors can have seriously affect the overall system reliability. There is the saying that for a "but for a nail the horses was lost, and but for the horse the battle was lost". This can be the case in critical system within DP vessels

System configurations are the classical area where reliability engineering is brought into the design of DP systems. The reliability will be assured by the use of redundant channels or paths on critical systems. For the design of DP vessels the use of DNV or ABS codes provides guidance on the ways to approach the problem.

The approach of addressing the systems reliability question by the use of codes and standards is that if the vessel complies with a particular DP class then reliability is assured. This is very much taking the code as a crutch though the design is only as good as the design and manufacture as shown above. The general approach used by the code is to perform some form of Failure Modes and Effect Analysis (FMEA) to identify single point failures. The use of the FMEA technique is a well-proven method of reliability engineers to route out single point failures, although the skill and knowledge of the analyst is essential. If the analyst is either not familiar with the system or is not provided with the correct technical support a weak FMEA will be produced which may not catch all single point failures, but which may used as a justification for obtaining a class certificate. There is the famous statement from the astronaut at launch who said that "our lives are riding on millions of dollars of equipment all procured from the lowest

When in operation the reliability, which is inherent in the design due to the above factors, is strongly influenced by the maintenance and operating schedule of the vessel. Poor maintenance will over time affect the reliability and availability of the vessel. Generally, though, the DP industry, which has had experience of the maintenance of DP vessel over a number of years, will have established a routine for the maintenance of vessels.

The above factors, which in general are applied to the design and operation of deepwater DP drilling vessels, have successfully addressed the problem of DP vessel reliability. Support for this statement can be found in the following:

- The feedback from the present generation of DP vessel should have removed many of the potential single point failure causes of disconnects. The experience outlined in reference (1) indicates that through the application of a detailed FMEA the mean time between failure was increased from 6 months to 2 years on a particular DP vessel.
- The rules of the class societies can be helpful but are not sufficient to ensure economically optimum reliability.
- Years of operating experience should have provided a basis for the knowledge to have been built up on the maintenance requirements of the systems.

Therefore, to conclude the analysis of individual system reliability data (thruster systems etc) is not considered to be meaningful and thus, another type of data should be collected.

What Type of Data should be collected

Given the complexity of a DP vessel and its operation the type of data that should be collected is an important questions which needs to be addressed. It is not the belief of the author that the collection of equipment specific failure data would serve any purpose to the DP industry. Whether one main diesel generator manufacturer is more reliable than another by say 500 hours mean time between failure, would not have a great influence on the availability of the system due to the general design principals used to provide redundancy. In addition such a figure would have very little meaning in terms of the statistical confidence, as the sample size is probably very small. In addition the collection of such data has been carried out by many of the general industry data banks (OREDA etc.). These databases provide the DP industry with acceptable reliability values that would have a better statistical confidence. Finally such an exercise is very costly to perform and also time consuming before any benefits can be derived.

Therefore one would have to ask the question of why should the DP drilling industry consider collecting disconnect event data. The reasons for the proposal to collect this data are outlined below.

- An influx of new vessels which will be placing a demand on the skill of the crews
- Provide a means of feedback to industry of problems that are been encountered
- Provide operators with a method of assessing the risks involved in the use of DP vessels.

Therefore the suggestion proposed is to answer the questions raised by the QRA of DP operations, namely disconnect "Event Data" should be recorded and analysed. The reasons for this statement are

- The recording of events of different categories will provide support to the overall value for DP vessel loss of station keeping.
- Analysis of the loss of station keeping incidents will provide feedback to industry.
- The collection and analysis should provide some form of root cause feedback to industry.
- As DP vessels are complex systems then analysis of overall system performance can be achieved by simple statistical techniques such as cumulative sums (CUSUMS)

What is meant by "Event Data"? It is suggested that the event data which should be analysed should consist of the classical "Loss of Station keeping" incidents. The Loss of Station Keeping should not be limited to a disconnect but should encompass all the events where operation had to be suspended. Therefore taking the "watch circles" outlined earlier, once the vessel has passed FJ1 then the incident should be analysed. This is suggested because there should be a correlation between the number of times a vessel exceeds FJ1 and then recovers (near miss) and the number of times a vessel exceeds FJ3 and requires a disconnect. This approach of recording "near misses" would have to be examined very closely to ensure that erroneous results are not produced.

As part of the analysis of loss of station keeping one of the major benefits to the DP industry would be to identify the underlying causes of the Loss of Station Keeping. This should allow categories of failures to be reported, such as

- Power Management System
- Power Distribution
- Power Plant
- Weather (Squalls, Thruster Capability etc.)
- Human factors
- Position reference
- Control Computers etc.

With regards to well control equipment the collection of reliability data is outside the scope of the Marine Technology Society, but the suggestion is that some other industry forum should consider it.

For the analysis of event data the most suitable source of data is the drilling contractors records of DP disconnect incidents. The reasons for this statement are:

- The source of the data is fully known.
- The data is relevant to the industry in which it is being collected.
- The operating environment is fully known.
- Analysis of the latest generation of drilling vessels would allow the data to start from a realistic time zero.

Data Availability

At least two of the largest and most experienced DP drilling contractors have made their failure records readily available. It is proposed that these be made public and that all new vessels join them in this openness. The data collection and analysis exercise should be an open forum for discussion and analysis. Through this openness it would be hoped that the whole industry benefits.

Session Index

What Benefit does industry achieve

Obviously this data collection and analysis should not be considered an academic exercise, but should provide the DP industry with a number of benefits. From previous experience of data analysis the data should provide information and feedback to the deepwater drilling industry in the following areas.

- Provide more robust values for assessment of the risks involved in deepwater DP operations
- The potential for a DP drilling contractors community to disseminate knowledge and experiences
- Allows the individual companies to benchmark their performance against other contractors. This it is hoped will lead to the development of an approach which foster the sense that improvements can always be made.
- Enables operators to review the deepwater industry as a whole and to provide a means of scoring drilling contractors.
- Provide a means of detection of in-service trends and identification of their causes in a quantitative form.
- Allow measurement of achieved performance against a specified reliability
- Allow operational staff and maintenance staff to identify in-service problems and then interface with their suppliers to resolve problems.

Proposal for a Way Forward

The above paper has outlined that there is obviously an area where the provision of accurate DP vessel disconnect event data would provide the DP drilling industry with more data to support the use of such vessel in deep water. Therefore if industry is in agreement with the idea of data collection, some form of pilot study should be undertaken to ensure that a full-scale project is feasible.
The following is a brief outline of the proposed way forward;

1. The DP committee of the MTS form a steering group to guide this effort.

2. Provide a proposal including costs and time schedule to the DP drilling industry.

3. Undertake a pilot study, which would provide a basis for developing the techniques for data capture and analysis. Funding in part by the DP committee.

4. The above approach might be undertaken as a Joint Industry Project (JIP) with a steering committee under the auspices of the Marine Technology Society (MTS) DP committee.

5. The DP industry including the main drilling contractors and operators would be asked to provide access to their data, which could be examined under a pilot study as to the suitability for a more broad analysis.

6. Funding would need to be worked out.

References

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2 The Reliability of Mechanical Systems J Davidson and C Hunsley The Institution of Mechanical Engineers 1994.
3 Dynamic Positioning Systems Incidents The International Marine Contractors Association.

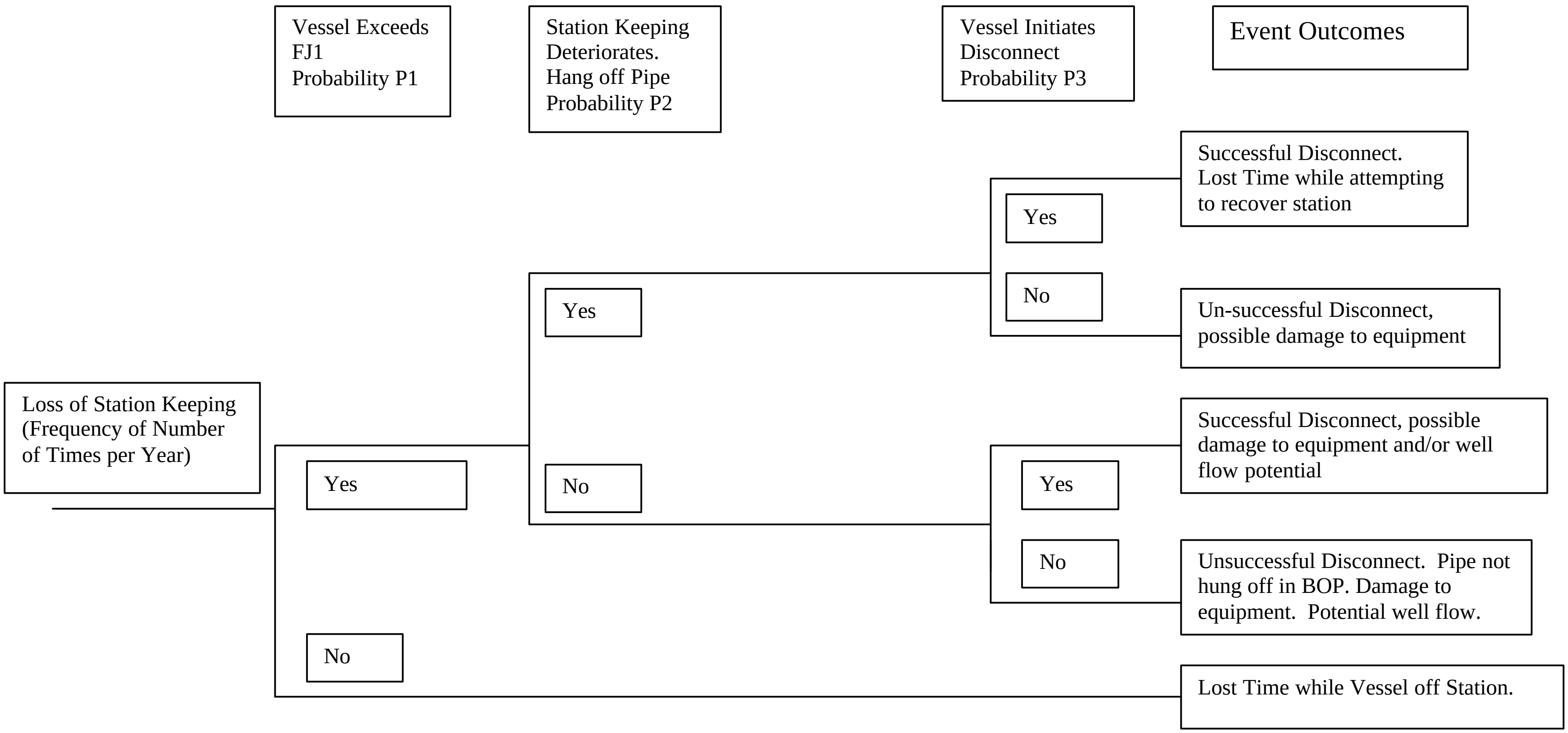

Figure 1.0 Simple DP Drilling Vessel Disconnect Event Tree