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ACCIDENT SEQUENCE PRECURSORS IN RISK MANAGEMENT FOR OFFSHORE INDUSTRY

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Abstract: *Active and aware risk management analysis of increasing offshore constructions development into the context of international trend in exploiting oil and gas reserves in high water depth, wind and wave power. Combining accident sequence precursor (ASP) from nuclear industry with probabilistic risk assessment (PRA) helped by innovative analytic hierarchy process (AHP) proposed by T. Saaty a software tool for evaluating risk is developed. Competent authorities in risk management (like MWS) could beneficiate from a standardised tool for risk evaluation and decision making used to maintain risk as low as possible at all times.*
Keywords: *risk analysis, risk management tools, offshore constructions, accidents*

SCOPE OF RESEARCH

Every enterprise can be affected by risks with potential impact on their single organizational parts or on their organizations as a whole. The awareness of consequences deriving from threats, omissions or adverse events drives enterprises to support risk management programs whose aim is to reduce undesirable consequences.
The qualitative analysis is very useful either when a preliminary risk assessment is necessary or when a human judgement is the only viable approach to risk analysis. However, since a risk state (likelihood and/or consequence) might change continuously, the data collection about it is a time consuming activity often perceived as an unjustified cost. Another problem is the timing; if data are not collected according to a real time modality, they are of little or any value as the actions anticipated by the contingency plan could be no more effective. These considerations inhibit the implementation of risk management systems. The top level model for process oriented risk management suggests how, at definition time, the organization of questionnaires and checklists can be arranged.
Risk assessments of marine operations events and conditions, which are performed by several methods today, require the benefit of standard procedures, methods, models, and formats. Such standards would enable the staff to avoid duplication of effort, inconsistent products, and conflicting results. Detailed documentation of analysis procedures and methods would also reduce the time required to complete routine risk analyses of operating events and licensee performance issues. In addition, improved documentation would enhance the internal and external communication of risk results.
Using as working example the ASP software SPAR developed under the supervision of Nuclear Regulatory Committee of USA, a full-sized risk management tool will be developed together with guidelines based on marine operations risk assessment history and accident precursor analysis based on past offshore disasters.
Risk assessment - process based tool using probabilistic risk analysis is currently in use by offshore inspection and maintenance departments operating in North Sea oil and gas developments. Anyway this tool covers operational phase in offshore development and not the preliminary phases of construction, installation and commissioning. Exactly those transitory stages create usual greatest risks involving asset lost, human injuries or death, environmental pollution and third party asset. Passively those risks are covered by Construction-All-Risks (CAR) insurance policy and internal safety mechanisms of various parties involved. Considering this variety of diverse safety systems based on experience, background, operating areas or industry the need of standardization for risk management becomes obvious.
Using the vast experience generated by half century of offshore constructions in interest of undersea hydrocarbons extraction, but also costal construction lessons learned and MOB operational events high precision and quality risk profiles could be made considering some practical criteria as nature of operation, place of development, tools & equipment used and profile of parties involved. Theoretical research is used to help in building a mathematical model to grant correct influence and likelihood for all determined precursors.

OVERVIEW

Development of undersea reserves of oil and gas, must take into account a large number of risks in the areas of human life lost, environmental disasters and material/financial assets wasted. All involved in offshore industry know those risks and the fact that major accidents are always likely to happen in this hazardous industry.
Eruption and then the explosion which tear apart Deepwater Horizon drilling rig last year on 20th April while workers were completing an exploratory well off coast Louisiana in Gulf of Mexico, developed into a tremendous human, economic but particularly environmental disaster. Why was this possible? Increase of oil price lately has encouraged oil and gas industry to drill in higher water depths. Macondo well was situated at 5000 feet below surface and reaching 13000 feet under sea bottom. [11]
Drilling in deep water is a technology young enough and not fully developed on matters of risk identification and mitigation, considering low temperatures and visibility or high distance and pressure. "When a failure happens at such depths, regaining control is a formidable engineering challenge - and the cost of failure…. can be catastrophically high" [2]
Risk element may be any decision that has a measurable probability of deviation from the initial plan. This of course presumes that this initial plan exists. Plans, strategies and procedures are the elements that facilitate foreseeing the reality and then comparison between results obtained and those expected.
Risk management is a cyclic process with several distinctive phases as: risk identification, risk analysis and risk mitigation measures. Identification of internal and external risks is of high importance as it allows managerial teams to point especially the internal risks.
Psychological approach on upper management regarding risks refers to their decisional behaviour. One subject must be able to choose between two or more alternatives, with different degrees of danger, uncertainty and randomness. Because during managing activities and especially during risk managing, decision factor is present in high percentage, is very influential to study the psychology of risk.
The reliability and safety assessment of operational systems should not only focus on hardware failure but also include human error. In a large-scale and complex industrial system, human is prone to produce various errors by the effects of error-forcing conditions. If a potential human error has a high occurrence probability or potential severe effects, this error is termed critical human error. To prevent and reduce human errors, it is important to identify these potentially critical human error modes by human error risk assessment. [3]

CURRENT RISK MANAGEMENT ENVIRONMENT

Theoretical risk analysis background

Risk evaluation tools [4] [5]
Currently for risk quantification purposes in industrial activities of high risk are used two basic tools: probabilistic risk analysis (PRA) and accident sequence precursor (ASP). Different as they are in methods and application, both end-up quantifying risk. Probabilistic risk analysis has its roots in aerospace industry and models complex systems with huge number of components, giving the probability of failure composed for entire assembly. As input for analysis we can consider statistic information on failure probability or in absence test data used

to predict it. Methods utilized for modelling are event trees and fault trees.

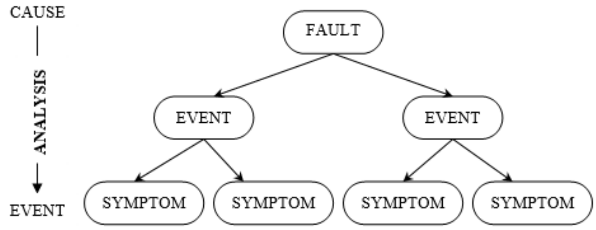

Figure 1 Fault tree

Event tree (Fig. 1) uses the symptoms that threaten the system and follow their progressive influence in each layer of engineering protections. Faults tree (Fig. 2) models the response of each component in case of a known cause, which grants study of different responses and construction of an overall system reliability image. This modelling may reveal lack of independence of engineered safeguards, missing redundancy, unusual mixture of system control and safety functions. The downside is the amount of data which is not always available or accurate. Human factor has also a great impact over those models as is difficult to anticipate his impact.

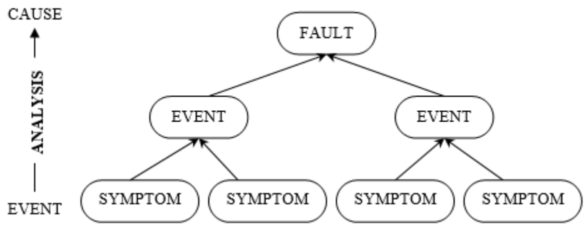

Figure 2 Event tree

On the other hand, event tree can model the response to a generic event and has the origin in nuclear industry where the facts were pretty much expectable (failure in cooling system that cools the reactor). Is feasible to obtain a general response of the facility containing information about all involved members (including human factor), but disregards specific details that may be essential in real situation.

Accident Sequence Precursor concept

Currently ASP is performed through strict format reports and specific guidelines to ensure capture of all possible problems. After collection of those report precursors of accident are identified and classified in initiating event and degraded conditions.

Identified precursors are iterated into the model with different generic tree of events having various initiating events. All the final results are ranked on their probability to create a disaster and that particular causal precursor. A recent study over the factors that lead to a risk-informed decision has resulted in following list:

- "Strong top management support and leadership both at the regulator and the licensee level;
- Education and training in risk principles and probabilistic risk assessment;
- A slow and steady introduction of risk initiatives in areas that can show value to both regulator and industry;
- A transparent regulatory foundation built around safety goals
- Development of a strong safety culture in industry allowing for more independence in safety compliance and risk management." [9][7][8][14][6][13]

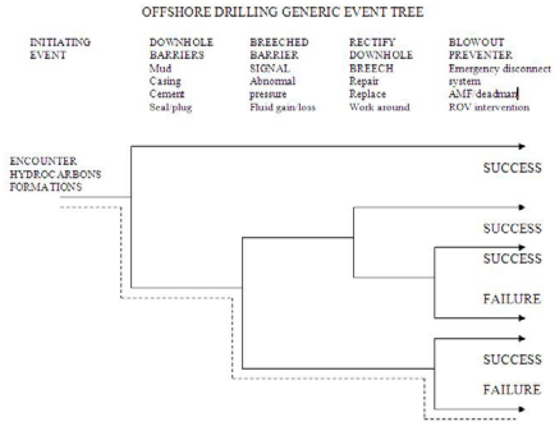

Figure 3 Event tree path for Deepwater Horizon disaster

Above event path shows exactly the barriers that accident path needs to cross. In these barriers the path finds allies represented exactly by the precursors of the accident.

The way to avoid is not only the legislation but also the technology must evolve to coop with challenges in deepwater environment. According to a study made by DNV over the remains of BOP and few spools of drill pipe, the preventer was not capable to fulfil his role.

Accidents occur when combination of events builds a pattern that defence systems fail to mitigate. It is often used similarity between Swiss cheese vs. risk management systems, holes being the precursor's path and apparent layers of cheese various layers of defence.

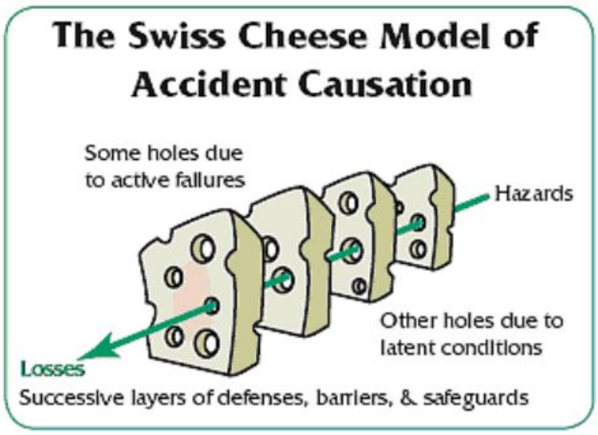

Figure 4 Swiss cheese model of accident causation (J. Reason 1990)

ACCIDENT SEQUENCE PRECURSORS DATABASE

Purpose of database

Development of a program on the existing safety reports regarding accidents, near misses and their corrective measures intends to create a guideline in the offshore construction industry. Database and associated software could have a wide range of scopes. Anyway main use intended is summarized below:

- to identify and quantitatively estimate the risk significance of operational events;
- to determine the generic implications of operational events and characterize risk insights from these events;
- to provide supplemental information on project-specific performance;
- to provide a check on PRAs (probabilistic risk analysis);
- to provide an effective indication of industry risk and associated trends.

Structure of database

This database is not unique, but merely an application of a existing method to a different environment, namely construction in offshore environment. Existing databases of

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ASP may be noted in nuclear industry (NRC database) and some trials in airspace industry (Pate-Cornell and Fishbeck).
Considering the existing background in oil and gas industry a wide range of reports of accidents might be use for the initial stage of the database. A scheme of information gathering is illustrated in the figure below:

Figure 5 Information gathering cycle

Data can be sourced from safety incident report, or collected during inspections, audits, safety evaluation and specific project/operation risk assessments. Input of specialists is required to analyze hypothesis of the incidents, to identify root cause and associated precursors. Method of considering this input is based on Multi Criteria Decision Analysis (MCDA) framework, utilizing the Analytic Hierarchy Process (AHP) to rank different precursors according to their impact.
Saaty scale will be used during pairwise ranking of precursors and robustness of model will be analyzed through a sensibility analysis which represents the tuning button for the overall risk profile. Increasing the weight of one or several precursors based on statistic values PRA based model will have the added value of practical experience.

Goals of database

Major accidents, and even major accident precursors are so rare events, that it is easy for an organization to loose focus and concentrate solely on prevention of occupational accidents. It is therefore essential that the indicators that are used have a certain volume of data, and some fluctuations regularly, in order to create the basis for maintaining high awareness and motivation.
Database constitutes a tool that will make the hidden faults obvious and bring low occurrence high consequences risk in the open. A few of the goals established are summarized below:
- Identification of precursor’s impact
- Prioritize or rank precursors
- Provide the results to the industry to be incorporated in design, operation or maintenance
- Periodic update with technological development, new regulations and hands-on experience
- Use latest risk models to evaluate consequences
- Adapt contingency measures at the industry level

Conclusions

All new safety concepts are reflected in costs increase for the industry, but not matches losses issued from lack of appropriate risk management and understanding of safety culture.
The total cost of the Macondo oil spill will include multiple categories of loss:
- Management and clean-up of the spill
- Claims by businesses, principally in the beach tourism and fishing industries, for loss of revenues resulting from the spill
- Claims and lawsuits relating to personal injury or death in the explosion, fire, and sinking of the Deepwater Horizon platform
- Environmental and natural resources claims for damage from the spill—from conservationists, fishermen, and states
- Health claims from those exposed to the oil or dispersants and other chemicals employed in the clean-up of the spill
- Product liability lawsuits related to equipment failures on the platform, subsea, or related to the containment of the spill
- Lawsuits filed relating to lost revenues for royalties, leases, or taxes from government entities
- Shareholders and securities lawsuits concerning mismanagement before and after the loss of Deepwater Horizon rig, leading to the dramatic reductions in share valuations that followed the spill
- Fines or other penalties

Similar accidents have also produced high losses for the companies involved in exploration, construction and production in offshore environment. Role of insurance companies is to oversee the operations, weigh the risk entangled and establish compensation for losses. As specialized arm of the insurance companies are highly specialized and experienced consultancy companies called **marine warranty surveyors**.
Marine warranty survey combines good engineering background with knowledge of international maritime regulation, commercial maritime law and good practical marine operation experience to stand as ultimate barrier in the Swiss cheese accident causation model.
UK Health and Safety Executive defined **safety culture** as “the product of individual and group values, attitudes, and perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management.” Safety culture has the implication of human factor in both her rams occupational safety and process safety.
As the implication of deepwater accidents keep increasing a natural decision is to adopt measures where risk assessment is far more developed. One of these industries is nuclear industry, where multiple study and research have come up with ASP program to evaluate the precursors long before an event could appear.
Use of a program feed with results of inspections, audits and lesson learned from previous accidents, saves the time and resourced spent of multiple reviews of the same peers or creating duplicative analysis. Database built this way could be start point of shared resource program as SINTEF is for blowout records.
“However, each time the industry has thought it was secure in its ability to anticipate problems and design defenses, new, unanticipated challenges have arisen, such as shut-down risk, stress corrosion cracking, and inadequacies in safety culture. The industry continues to learn, forget, and relearn a difficult lesson—that anticipation must be combined with resilience in responding to precursors.” (Marcus and Nichols, 1999; Weick et al., 1999; Wildavsky, 1988) [1] [10] [12] [15] [16]

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