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Equipment Reliability Data Collection: A Journey to Operational Excellence in the Offshore Industry

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Abstract: The offshore industry has witnessed catastrophic incidents, which continue to occur. There is a need to learn from various best practices and incidents and continue to move towards safer operations. Data in different forms on equipment reliability, near misses, key performance indicators and more exists within organizations and agencies in this industry. Most of these databases, if collected and connected could be used to prevent and/or assess the consequences of an event. Near-miss databases can help to assess the barriers that would prevent an event from escalating to consequences, and the reliability databases can be used to assess the barriers that can prevent an event.

This paper describes the experience, initiatives and major challenges of the Ocean Energy Safety Institute (OESI) and the Mary Kay O'Connor Process Safety Center (MKOPSC) in data collection projects and initiatives. The paper concludes with next steps to see how existing databases could be improved in areas such as data quality, data validation, increased accessibility and searchability and provides a list of potential research projects.

1. Introduction

With multiple catastrophic incidents to draw lessons from, along with numerous near-miss events continuing to occur, the offshore oil and gas industry must continue to increase their understanding of equipment reliability. This increase in visibility of reliability should not only be focused on safety-critical barriers, but should also include operationally relevant equipment as well. By understanding system-wide reliability, a more focused depiction of risk can be realized.

2. Background information and motivation

On July 6, 1988, a series of catastrophic explosions occurred in the production platform of Piper Alpha, resulting in 167 fatalities and the loss of billions of dollars. According to the investigation, inadequately protected equipment gave rise to damaged pipe. Malfunctioning emergency equipment was another concerning finding in this incident [1],[2].

On July 27, 2005, a multi-purpose support vessel collided with a gas export riser in the north platform of the Mumbai High Field, India's largest offshore oil and gas field. This disaster caused a dramatic fire, 11 fatalities, and heavy damage of the platform. The emergency shutdown valve of the gas export riser did not work properly and lead to the explosion [3],[4].

On April 20, 2010, the Macondo blowout occurred in the Gulf of Mexico shocking the world. 11 deaths, the loss of the Deepwater Horizon, and over 5 million barrels of oil discharged into the Gulf of Mexico. Confined by design capability, the manually operated blowout preventer was not closed promptly in this incident. [5].

Lessons should be learned from these catastrophes. Equipment reliability is an important part in these major offshore disasters. Unsound equipment can lead to loss of containment events, and can also make the consequence more severe. According to an investigation among 6,183 accidents based on the World Offshore Accident Database, equipment malfunction is the primary cause (34%), giving it a contribution higher than cause of ignition (26%) and weather condition (25%) to these events [6]. Equipment reliability should be taken into significant consideration, and collection of necessary data involving equipment reliability is required to help prevent similar catastrophes.

The Ocean Energy Safety Institute (OESI) is a collaborative initiative committed to offshore energy-related technologies and activities for safer and environmentally responsible off-shore operation. The institute concentrates efforts to identify scientific and technological gaps and gives recommended suggestion in operation and production equipment. The primary mission of the OESI is to provide a forum for promoting dialogue, shared learning and collaborate research among academia, the oil and gas industry, regulators and other non-governmental organizations, and developing strategic cooperation within the area of offshore drilling safety and incident prevention.

The mission of the Mary Kay O'Connor Process Safety Center (MKOPSC) is to "Make safety second nature" in the process industry by minimizing losses through improved safety processes, equipment, procedures and management strategies. For integration of process safety, the center emphasizes education, research and service in safety engineering. To promote development of safety technologies and make the industry competitive, MKOPSC provides a communications forum, and generates projects and other related opportunities that will encourage long-term progress in the field of process safety.

Equipment reliability data is not only essential for risk assessment modeling and safety tools, but is also indispensable for developing equipment specific leading risk indicators and maintaining overall safe and reliable operations.
It is important to start from the basics and establish a master equipment list. But building the

list only from the P&ID (Piping and Instrumentation Diagram) is not enough; the list should include other components like cranes, water makers, safety equipment, and out of service items. Once the equipment list is created, it should be kept updated, using the MOC (Management of Change process). A Process Reliability Criticality Assessment should then be used in developing spare parts lists as well as in understanding which pieces of equipment should have emphasis placed on them in creating preventive maintenance task lists. From an equipment reliability perspective, preventive maintenance aspects need to be considered. Such data can be obtained from OEM (Original Equipment Manufacturer) and qualification of personnel conducting the maintenance. A lack of reliability will result in downtime. Therefore, it is important to track downtime and to understand how production loss is tied to specific pieces of equipment and what areas of production. When producing metrics from reliability data, the data needs to be detailed enough to calculate quantities like MTBF (Mean Time Between Failure) and can also be used to calculate the full loss of opportunity of a failure. Keeping up with the data is another major issue that brings the question on how data is stored. Data can be stored in spread sheet, manual paper system or in a CMMS (Computerized Maintenance Management System). Data should be stored in a way it can be easily queried, understood and shared.

Driven by the deficiency in systematic data collection platform, The Instrument Reliability Network (IRN) was established through the MKOPSC for a better collaborative network of companies [12]. The mission of IRN is to share historical information and lessons learned in order to minimize environmental harm, improve industry safety, maximize asset performance and reduce maintenance costs through better lifecycle management of instrumentation and controls applied in the process industry. Sponsored sub-networks include technical network and business network. Two webinar conferences and one face-to-face symposium are being organized within IRN per year.

The 70th and 71th Instrumentation and Automation Symposium, successfully hosted by MKOPSC, presented the latest improvements on instrumentation reliability and continually offered attendees opportunities for constructive discussion over important topics. Through the Instrumental Reliability Network, over 300 attendees shared their experience in this field. Topics of the discussion included, functional location and equipment, notifications and orders in the failure data collection process, and advanced development of methodology and technique to improve the understanding of instrumental reliability.

There is a great importance to collecting the appropriate reliability data, correctly and thoroughly analyzing it, developing knowledge and sharing it with partners across the industry. It is important to have data as it can measure progress, assess trends, assign priorities, inform risk assessment, and improve safety performance. Data is important, but data can also be dangerous if not used properly. Problems for data, such as data availability, quality of data, and barriers to data sharing, are well known. Some of the initiatives related to equipment reliability are the start of a journey to improve data quality and to make data available for sharing.

3. OESI initiatives

With the purpose to leverage and facilitate learning in the offshore safety realm, OESI has organized various forums, which have included:

- Risk - risk awareness risk perception and using the awareness and perception in making operational decisions on a continuing basis
- Eliminating Barriers to Sharing Data, and the Solutions
- Research - Ocean Energy Safety Research Roadmap for the 21st Century
- Human Factors - Decreasing Ocean Energy Safety Incidents through Greater Incorporation of Human Factors and Human-Systems Integration
- Blowouts in Shallow Water - Maintaining a High-level of Focus and Increasing the Safety Culture in the Shallow-water Operating Environment
- Taking SEMS to the Next Level
- Managing Barriers for Safer Offshore Operations
- Managing Alarms for Safer Offshore Operations

Specifically, during the Data Forum the dialogue surrounding equipment reliability, near-miss collection, and lessons learned from accidents (High Value Learning Events (HVLE)), brought to light the requirement for an entity to coordinate an offshore reliability database. As future work, it was recommended that OESI first catalog the existing databases and list what problem each database is trying to solve and how the analysis of the collected data improves the decision making. This catalogue will also help to identify the gaps in the overall picture of data collection. From that catalogue, recommendations could be made on how existing databases could be improved in aspects like data quality, data validation, and on how to make them more accessible and searchable. It is important to learn from the successful data collection initiatives to see how they have overcome their own barriers.

The follow-on literature search for reliability databases identified 19 reliability databases, of which 6 are entirely dedicated to offshore equipment, 4 are dedicated to the petrochemical industry in general, 2 for the nuclear industry, and 7 which could be useful for all industries. The search also identified 13 lessons learned databases, 4 Key Performance indicators (KPI) databases, and two near-miss databases. The breakdown is shown in Figure 1.

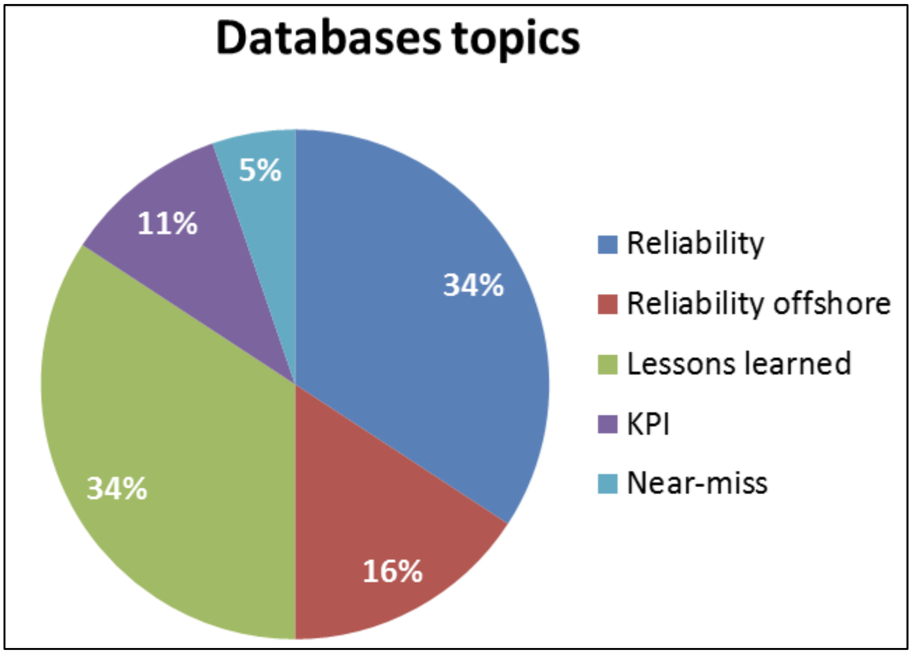

Figure 1: Database inventory project topics

The major identified databases that collect offshore-related equipment reliability information are OREDA (Offshore Reliability Data), Well Master ExproSoft, Subsea Master ExproSoft, Reliability of Deepwater Subsea BOP Systems, Well Kicks SINTEF Reports and PDS Data Handbook. Table 1 provides the following details of reliability databases: description of the targeted facility, targeted equipment, and objective of the data collection, if the return on investment is specified, region, and type of data (regulatory, private *etc*., accessibility, size and timeline of data collection. The OESI Data Forum also identified that one path forward in the future of data collection and sharing was to identify the Return on Investment (ROI) for companies who share the data. Since this study was completed, the Center for Offshore Safety (COS) has developed their own database which includes Safety Performance Indicators and Learnings from Incidents.

Table 1: Reliability database [7-11]

Offshore Facilities									
Database	**Targeted Facility**	**Targeted equipment**	**Objective of database specified?**	**Return on Investment specified?**	**Region? (US, GOM, North Sea...)**	**Regulatory or private initiative?**	**Accessibility of the data**	**Size of Database**	**Timeline of data collection**
OREDA (Offshore Reliability Data)	Primarily Offshore, but also onshore facilities	Offshore subsea and topside equipment and onshore equipment	Collect and exchange reliability data among the participating companies	No	Global (data comes from member companies	Private	Database + software only available to members, book can be bought	Data from > 265 installations, 16,000 equipment units with 38,000 failure and 68,000 maintenance records	Since 1984.
Well Master ExproSoft	Offshore facilities (Components in oil wells)	Well Reliability and integrity	Risk and reliability studies	No	Global	Private	-	30,000 well years of experience data for more than 5,000 wells in major oil and gas producing regions	-
Subsea Master ExproSoft	Offshore facilities (Components in oil wells)	Components in subsea oil/gas production systems	Risk and reliability studies	No	Global	Private	-	-	-

Reliability of Deepwater Subsea BOP Systems and Well Kicks	Offshore facilities	BOP (Blowout Preventer) systems	-	259 wells	-	-	Available	259 wells	Since 1978
SINTEF Reports (PDS Data Handbook)	Primarily Offshore, but also onshore facilities	Offshore subsea & topside equipment and onshore equipment	No	OREDA database and handbook	-	Private	Available	Data source from OREDA database and handbook	Since 1998
PDS Data Handbook	Offshore & Petroleum Industry	Components of control & safety systems; field devices & control logic, data for subsea equipment, drilling, new topside equipment	No	No	Norway	Private	Need to purchase	-	-

As shown in Figure 2, the reliability databases can be used to assess the barriers that can prevent an event. Therefore, future data collection initiatives should focus on both the barrier assessment and operational equipment.

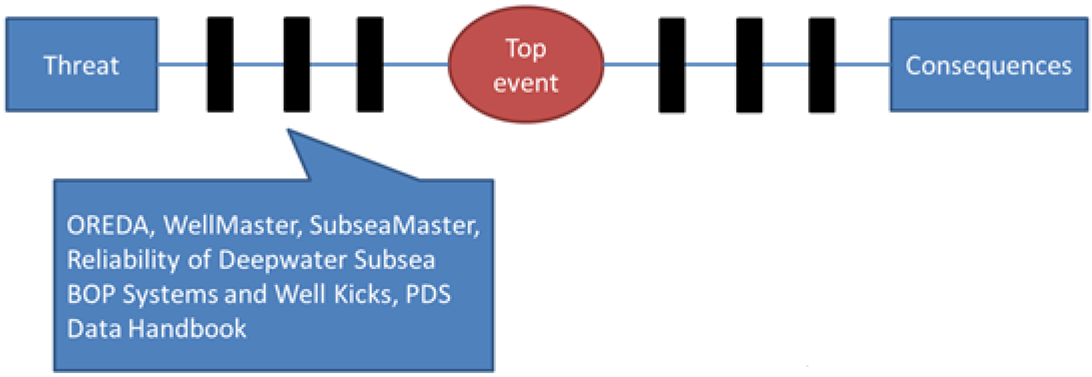

Figure 2: Reliability data usage in a bow-tie

4. **Way Forward**

The proposed Outer Continental Shelf Reliability Network (OCSRN) Database will be an effort by the process industries in collaboration with the Ocean Energy Safety Institute (OESI) to ease this challenge through the collection of relevant failure data. The data handling protocol will be a part of the OCSRN documentation and designed to ensure the anonymity of member companies providing data for the OCSRN database. Figure 3 presents the hierarchy of OCSRN documentation.

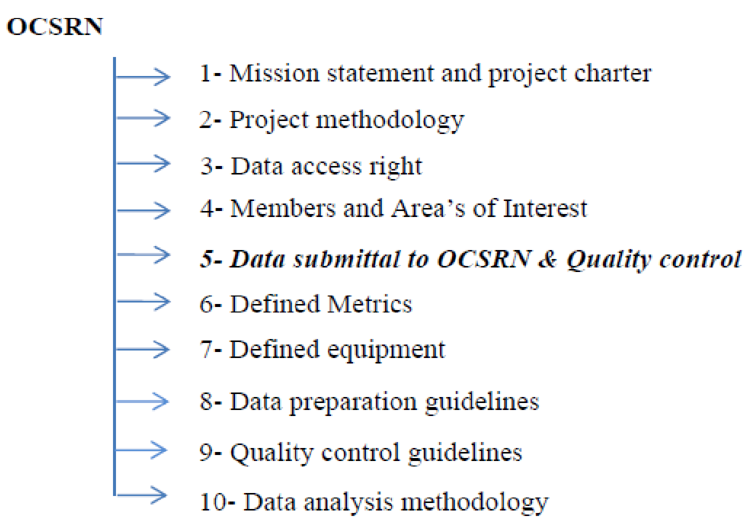

Figure 3: OCSRN documentation hierarchy

The data handling protocol details how reliability data is transferred from member companies to OESI before being converted into data in the OCSRN database. It is used, in conjunction with other OCSRN documentation, to prepare detailed procedures for each of the steps in this protocol. The protocol consists of four main steps:

- Step 1: data preparation at member companies
- Step 2: data submission to OESI
- Step 3: data quality control at OESI
- Step 4: data analysis at OESI

Figure 4 presents the general flowchart of data from member companies to the final OCSRN database.

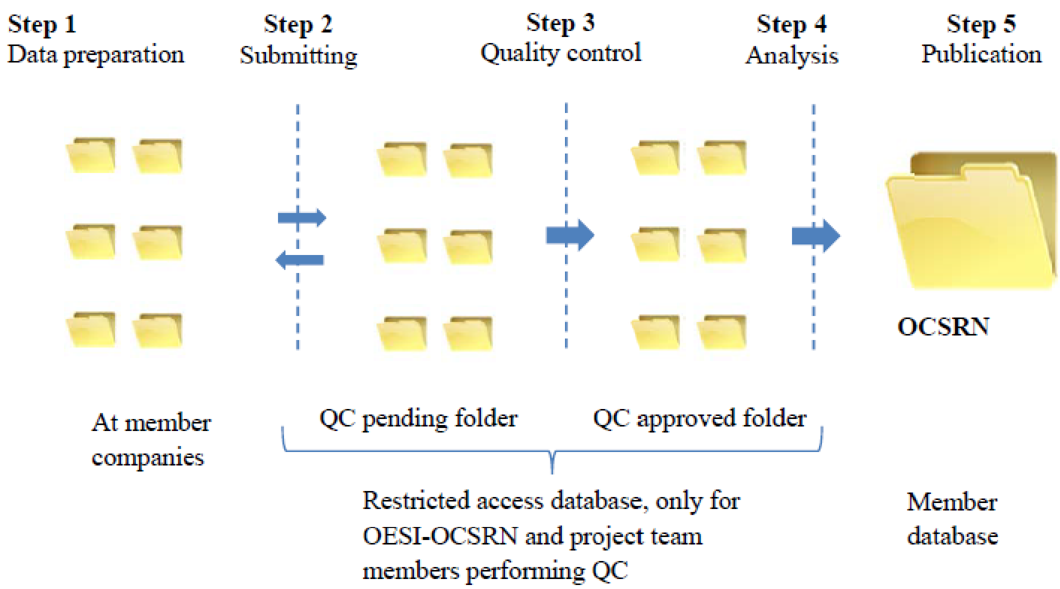

Figure 4: General scheme of data handling protocol

The QC pending folder and QC approved folders will be managed by two separate and mutually exclusive teams selected by OESI and the OCSRN steering committee in order to better ensure anonymity. These teams are the OCSRN QC team, which will manage the QC pending folder and decide if datasets are ready to be migrated into approved folder; and the OCSRN Data Analysis team, which will manage the QC approved folder. The two teams will have sole access to their respective folder and will not be allowed to access the other.

5. Limitations and obstacles

As identified in previous OESI Forums, and earlier in this paper; there are certainly barriers to developing and executing an OCSRN. One significant barrier is the proprietary nature of much of the data collected offshore. This barrier can be mitigated with the involvement of data and legal experts. Developing dialogue around this subject should inform a way forward. Additionally, much of the data to be collected is not only proprietary, but is also of multiple formats. Again, through dialogue either standard formats could be developed, or data translators may also be developed to ensure like data is being collected and compared. A third obstacle, is understanding what data should be collected. With today's (and tomorrow's) technology the proliferation of data available outstrips the collection and analysis capabilities. Key data and parameters should be identified that will provide the best visibility into reliability of offshore safety equipment.

6. Summary

While much data is collected in the offshore realm, the efforts are multiple and not well coordinated. Additionally, is the correct data being collected to develop an understanding of reliability? Informed by these multiple collection efforts and the MKOPSC IRN, the Ocean Energy Safety Institute is working to develop the OCSRN to support risk-based decision making, and further enable safer and environmentally responsible ocean energy operations.

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