engineering proceedings

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Proceedings Paper

A Case Study for Implementing Plant Corrosion Inspection and Maintenance Anomaly & Integrity Management System on Sabratha Gas Production Offshore Platform in the Mediterranean Sea †

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† 2nd International Electronic Conference on Applied Sciences, Environmental and Sustainable Science and Technology, 15–31 October 2021.

Abstract: Corrosion and maintenance anomaly & integrity management systems (AIMS) are now the foundation of many industrial and engineering systems in point of sustainability and long-lasting assets. The oil and gas industry started developing new integrated management systems to keep its assets safe in its life cycle without real external failures. However, the overlapping of assets' integrity responsibilities occurs when a conflict of interests, such as production, safety, environmental, and financial interfacing, are inaccurately weighed against each other. This paper will review the case study of anomaly and integrity management systems implemented in the Sabratha offshore platform. In order to achieve sustainable asset implementation, it is essential to figure the different weights given to the critical factors controlling operational anomaly and integrity of facilities on an offshore platform and re-classified the potential failures. So, design practices are reviewed. Also, Inspection techniques and strategies are re-assessed and used to describe the consistent integrity assessment techniques which linked to anomaly monitoring and maintenance criteria. Finally, the anomaly and integrity management system design use activity, process models, structures, and flow diagrams. The work will be helpful for the further enhancement of a new machine learning system to support this approach.

Keywords: failure analysis; oil & gas offshore platform; risk-based inspection; corrosion; maintenance assets integrity management

Citation: Mussa, M.H.; Dukali, M.; Rahaq, Y. A Case Study for Implementing Plant Corrosion Inspection and Maintenance Anomaly & Integrity Management System on Sabratha Gas Production Offshore Platform in the Mediterranean Sea. *Proceedings* **2021**, *68*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s):

Published: date

1. Introduction

Offshore structures such as Fixed offshore platforms, Compliant towers, Semi-submersible platforms, Jack-up drilling rigs, Drillships, Floating and production systems, and the subsea system, as shown in Figure 1, are considered costly capital assets in the offshore oil and gas industry [1,2]. Therefore, they need exceptional management to mitigate and avoid disasters, shutdowns, corrosion and unnecessary emergency failures by using a reasonable inspection and anomaly reducing control system [3].

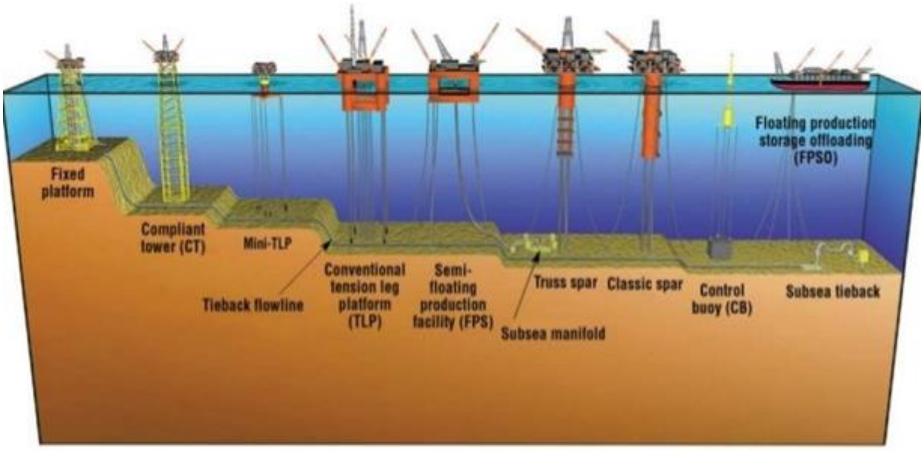

Figure 1. Shows offshore rigs and marine structure platforms [4].

As of now, there are many mitigation management systems designed on inspection-based time (TBI) or risk-based inspection (RBI). Therefore, risk identification and evaluation techniques (RIET) are critical for designing any assets anomaly & integrity management systems. Many of these techniques, including hazard and operability study (HAZOP), hazard identification study (HAZID), fault tree analysis (FTA), human reliability analysis (HRA) and failure mode effect and Criticality Analysis (FMECA), can be used to design decent mitigation systems for offshore facilities [5,6].

In the past decades, world statistics failures reports from marine, oil and gas industries exhibited that the causes of significant accidents and explosions on offshore structure systems were from equipment and facilities failures, operation errors, artificial damage, natural disaster and unknown reasons as it showed in Table 1 [6].

Table 1. Percentage of causes of major accidents and explosions on marine and offshore rigs and platforms.

Equipment and Facilities	Operation Errors	Artificial Damage	Natural Disaster	Unknown Reasons
40%	20%	12%	10%	18%

Since the offshore platform contains complex integrated systems arranged by hundreds of pipes, pressure vessels, auxiliary equipment, and machines, it could also contain a process production system with specific series characteristics, also the living quarter in the top of it, which make the place riskier than the onshore production units [7]. The offshore platform production system has some characteristics that could increase onboard risks, including dealing with inflammable and explosive materials, high temperature and high pressure, aggressive corrosion, and rough working conditions [8]. Half of the major accidents can be avoided if equipment and facilities will be inspected, maintained and managed systematically and stratigiclly [6]. Therefore, looking to reduce the impact of failure could cause catastrophic disasters. Scheduled maintenance is not enough to avoid unexpected circumstances. The strategical risk-based inspection of critical facilities, pressure vessels and the high-risk piping system could reduce the likelihood of accidents [9]. However, the overlapping in responsibility between the operation sections on the offshore platform could reduce the effectiveness of the mitigation action. That is why we shall clearly define the responsibility and action plan with an easy understanding of the process flowchart [10]. This Case study will review the anomaly and integrity assets management system procedure implemented on the Sabratha platform. It will cover the period from 2010 to 2014 of implementing the procedure in the offshore field; Sabratha Platform has located 110 km from the Libyan coast in Bahr Essalam offshore field. The platform, considered one of the biggest Libyan Offshore condensate and gas production units, is fixed to the seabed in a water depth of 190 m, as shown in Figure 2. The platform consists of all of the facilities required for preliminary separation and treatment of the gas produced from Bahr Essalam field as well as a fast-moving workover rig (FMWR), a helideck and living quarters for 120 persons [11].

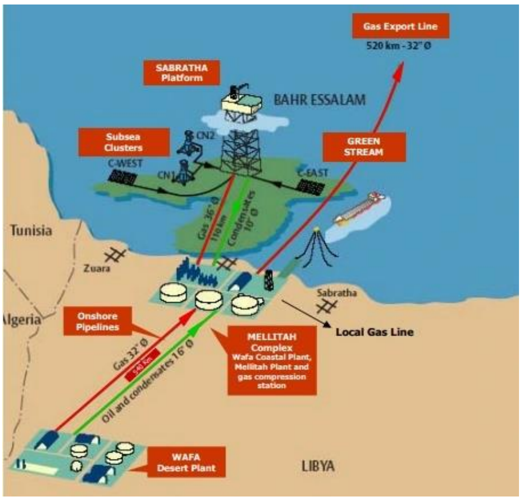

Figure 2. Location of the Sabratha platform in front of the Libyan coast in the Mediterranean Sea [11].

2. Methodology and Procedure

2.1. AIMS System Overview

Figure 3 show the flowchart procedure that was implemented onboard [5,12]. The Corrosion inspection and maintenance anomaly & integrity management system (AIMS) objective is to identify the risk of an anomaly in the early stage so that mitigation plans can be developed and appropriately implemented with clear responsibility and actions. The purpose of this management system is to brief the requirements to record anomaly occurs in the pressure system, and critical facilities followed up the mitigation, including maintenance ad replacement, to resolve any anomaly that might threaten the integrity of the offshore facility.

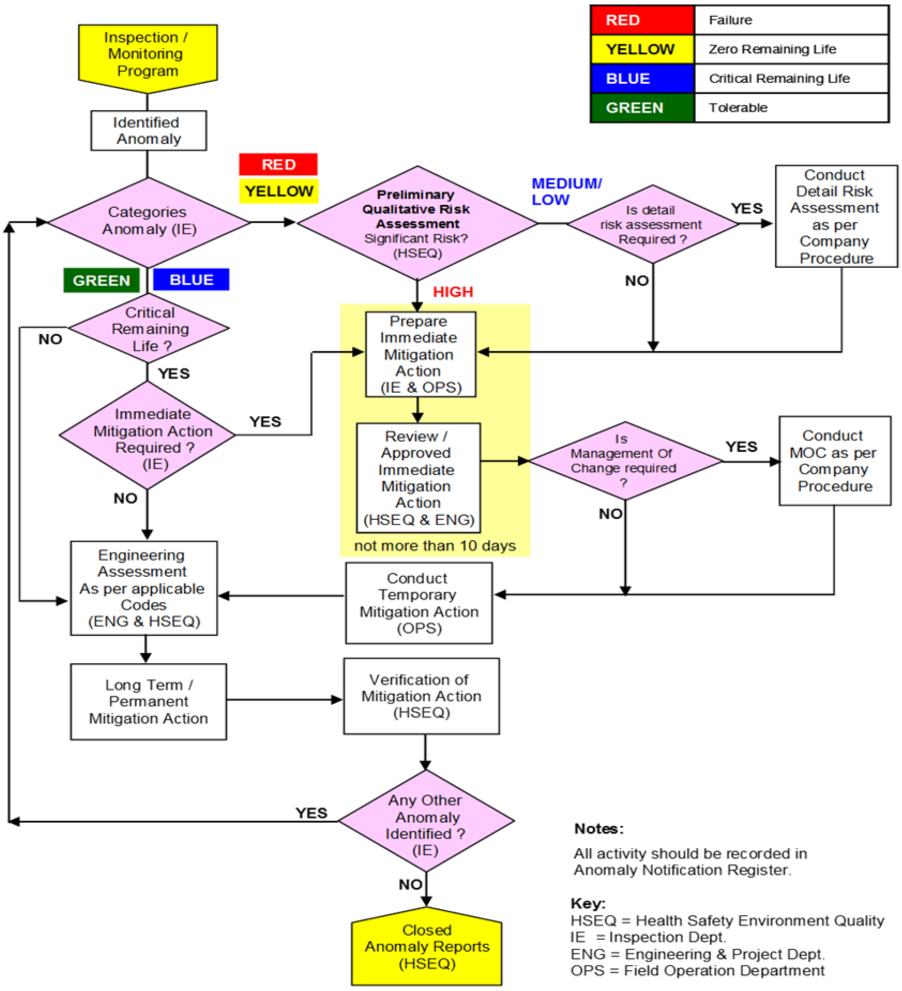

Figure 3. System flowchart procedure, shows the action and decision making based on The Corrosion inspection and maintenance anomaly & integrity management system.

2.2. Responsibilities of Departments

Table 2 summarizes the responsibilities in the procedure according to the flow of the required work based on risk identification of the platform equipment's, including inspection, planning, maintenance, and continued improvements.

Table 2. Shows the responsibilities of departments in the implemented system.

HSEQ Department	• Ensuring compliance with this procedure. • Reporting to chairman regarding the anomaly status • Notify all related parties to take immediate action if there is a critical anomaly that may affect the integrity of the plant and lead to unsafe operating conditions. • Acknowledge and brought the individual Department attention-related the anomaly status of their operation. • Performing detailed Risk Assessment with the Engineering department • Performing integrity analysis for existing anomalies. • Registering the received transmittal • Monitoring the status of anomalies • Review and approved Short-term/Temporary Mitigation Action Recommendation • Closing Long Term/Permanent Mitigation Action Recommendation • Review and approved company procedures as required

Engineering Department	• Performing detailed Risk Assessment with the HSEQ department • Performing support in engineering analysis for existing anomalies. • Issue recommendation for permanent mitigation actions • Issue recommendation for any Plant Modification Request as a result of the Engineering Assessment. • Provide necessary documents, calculations, etc for detailed execution work of long-term mitigation actions. • Review and approved company procedure as required
Inspection Section	• Defect reporting. • Performing Preliminary Qualitative Risk Assessment • Raising an Anomaly Notification • Distributing the transmittal to the relevant parties • Verifying that any mitigation actions in the maintenance management software MMS (MAXIMO) have been appropriately taken • Verifying any field procedures available as required according to the approved procedures. • Discuss the short-term mitigation action with the field operation department.
Operation, maintenances, and production Department	• Discuss the short-term mitigation action with the Inspection Engineer. • Follow the short-term mitigation action as agreed. • Issuing a Work Order for Short Term/Temporary Mitigation Actions Recommendation • Issuing a Work Order for Mitigation Actions Recommendation • Entering Mitigation Action to the maintenance management software MMS (Maximo) for follow up and monitoring. • Issuing a Plant Modification Request as necessary or following the Engineering Department recommendation.

2.3. Evaluation of Using the Database Results

By using the system from the period 2010 to 2014, it showed that the platform contains over 163 pressure vessels equipment from the process and auxiliary facilities. These pressure vessels have been identified to two categories according to the risk as safety-critical equipment (SCE) and non-safety critical equipment (non-SCE), Figure 4, shows the pie chart of the inspected pressure vessels within the four years.

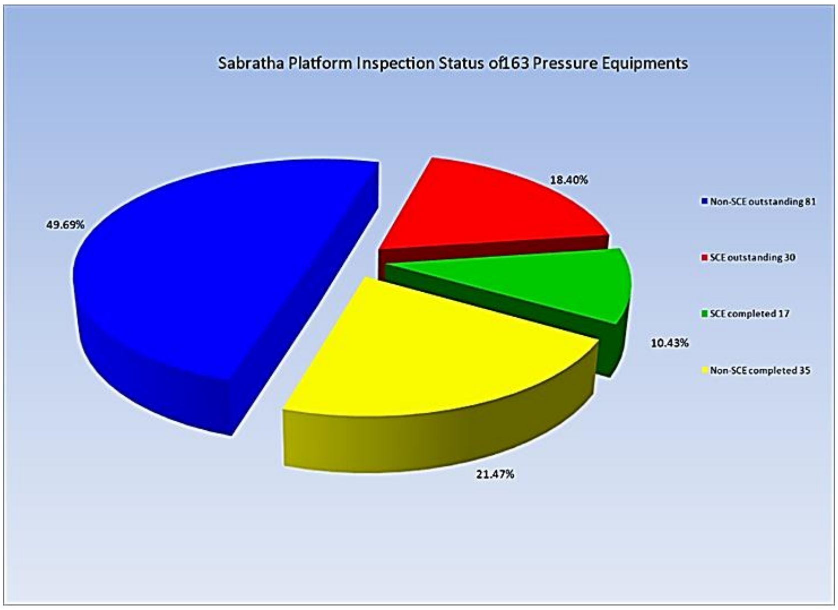

Figure 4. Sabratha Platform inspection status of pressure vessels and equipment.

As the design requires, the pressure vessels and processing pipes system shall be fitted with safety pressure valves (PSV). These PSV's on the platform should be inspected and recalibrated a minimum once every two years; the total number of PSV's onboard is 198 PSV. Figure 5 shows the total inspected and calibrated PSV valves per the reviewing period.

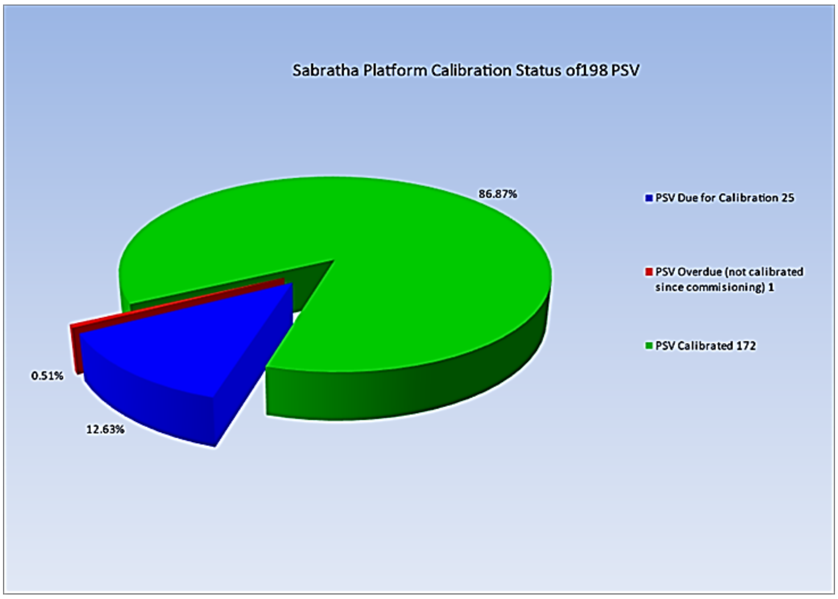

Figure 5. Sabratha Platform inspection status of pressure safety valves.

From the implemented system, It could obtain the inspected and calibrated data for the safety-critical equipment and other equipment and show the trend of required maintenance that shall take action or according to that change the periodic inspection and maintenance plan accordingly as it showed in Figure 6.

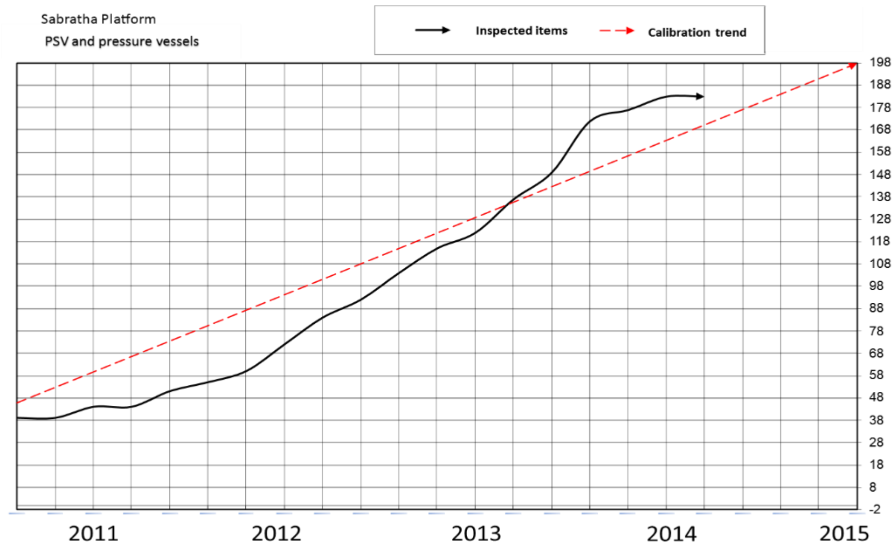

Figure 6. the real statues of inspected PSV and pressure equipment in four years.

4. Conclusions

Offshore Corrosion Inspection and Maintenance Anomaly & Integrity Management System (AIMS) has become the mainstream system for safe gas operation management of the equipment and facilities on the Sabratha offshore platform. With the implementation of this management on the offshore platform, it is clear that the inspection priorities and mitigations action are well maintained to avoid any shutdown or accident could happen, the AIMS system has changed from dealing with an inspection from qualitative to quantitative, and this system could be applied on other fields including onshore and desert oil and gas fields

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are not publicly available; The data files are stored on corresponding instruments and personal computers.

Acknowledgments: The authors would like to acknowledge the facilitating support by Mellitah Oil & gas BV for data resources.

Conflicts of Interest: The authors declare no conflict of interest.

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