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Structural Integrity Management for Fixed Offshore Platforms in Malaysia

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Abstract**—**Structural Integrity Management (SIM) is important for the protection of offshore crew, environment, business assets and company and industry reputation. API RP 2A contained guidelines for assessment of existing platforms mostly for the Gulf of Mexico (GOM). ISO 19902 SIM framework also does not specifically cater for Malaysia. There are about 200 platforms in Malaysia with 90 exceeding their design life. The Petronas Carigali Sdn Bhd (PCSB) uses the Asset Integrity Management System and the very subjective Risk based Inspection Program for these platforms. Petronas currently doesn't have a standalone Petronas Technical Standard PTS-SIM. This study proposes a recommended practice for the SIM process for offshore structures in Malaysia, including studies by API and ISO and local elements such as the number of platforms, types of facilities, age and risk ranking. Case study on SMG-A platform in Sabah shows missing or scattered platform data and a gap in inspection history. It is to undergo a level 3 underwater inspection in year 2015.

Keywords**—**platform, assessment, integrity, risk based inspection.

I. INTRODUCTION

THE Malaysia Oil and Gas (O&G) industry has expanded tremendously since its early days of the 1900s. The inclusion of Shell and Esso into Malaysia O&G has increased Malaysia capabilities in the exploration and production of oil. The Petroleum Development Act 1974 established state owned PETRONAS with exclusive rights of ownership, exploration and production of all oil and gas inside the country. PETRONAS enters into Production Sharing Agreements with other petroleum companies, which explore, and develop these resources.

There are about 200 platforms at present operated by various operators in Malaysia; hence there is a critical need for a systematic structural integrity management (SIM). Figure 1 shows the time line in the development of Malaysian O&G Industry. The first PSC contract was awarded to ESSO in 1976 and subsequently many fixed offshore structure were installed in Malaysia. In these discussions, only platforms belonging to PCSB have been considered, since there are limitations in obtaining data from other operators because of confidentiality agreements.

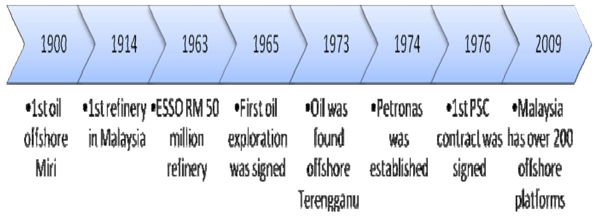

Fig. 1 Timeline in the development of Malaysian O&G Industry

PCSB is currently undertaking the structural integrity assessment covering 175 platforms and 4 FSO/FPSO within Peninsular Malaysia Operation (PMO), Sabah Operation (SBO) and Sarawak Operation (SKO). The types of platforms range from drilling, wellhead, production, gas compression, living quarter, vent and riser. Many of these platforms are over 20 years old and 51.42% of them have exceeded their original design life of 25 years. Furthermore, there are 23 very high risk platforms based on the latest Risk Based Inspection (RBI) status which constitute to 13.14% of the 175 platforms and 4 FSO/FPSO within PMO, SBO and SKO.

The main objectives of this study are

- To develop an understanding of the SIM issues in Malaysia by studying Structural Integrity Management of platforms in Malaysia
  - Recommendations for SIMS in Malaysia
  - Interviews were conducted with Industry specialists.

- To carry out a SIM case study of an offshore platform in the four steps below:
  - Identify the location of the platform and collect the platform data.
  - Obtain the inspection history.
  - Identify the gaps in the inspection program.
  - Recommend the future program for inspection

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II. Methods and Materials

Literature Review

Figure 2 shows the evolution of design process in fixed offshore platforms. The first edition of API RP 2A[1] which used the working stress design was issued in 1969 [2]. Structural design has evolved over the years and 22 editions of the code have been published. Prior to the 7th edition (1976) return period of the wave was not specified and both 25 year and 100 year waves were used. After the 7th edition, 100 year wave became standard practice. The 20th edition (1993) introduced a new wave formulation and recommended using 100-year load condition. These changes with higher recommended drag coefficients have led to design loads that are 2 – 4 times higher today than they were for early generation platforms [3]. In 1993 the first edition of the Load and Resistance Factor Design (LRFD) version of API RP 2A was issued [4].

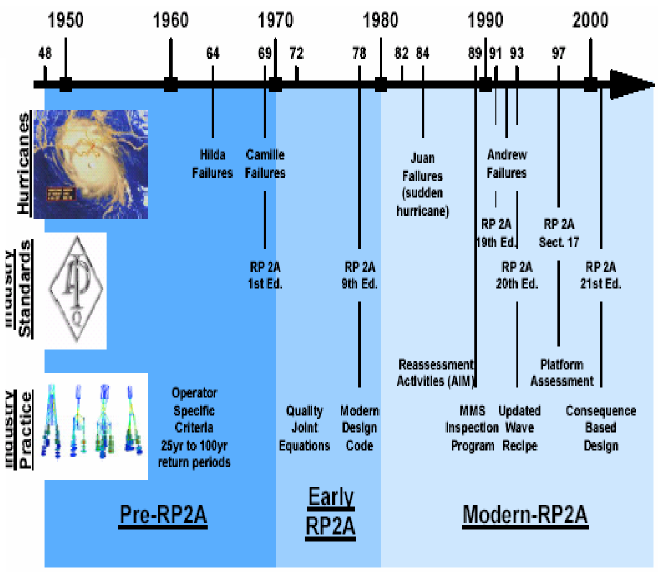


Fig. 2 Evolution of Platform Design [5]

The history of SIM can be traced back to 1948 when the first fixed offshore platform was installed in shallow water off the coast of Louisiana (in USA). Component design approach was used for its design. This approach has served the society well; indeed, experience from in-service performance suggest that well maintained platforms are more robust and damage tolerant than a component based design approach would indicate [5]. But most of these platforms have now exceeded their design life and are over 30 years old.

Because of this, in the early 1970s or so, engineers had to develop a new approach as an alternative to the component based design checks to ensure that their platform is fit for purpose and safe for use. As a result, new maintenance guidelines, assessment procedures were developed to better exploit the full capacity of offshore structures.

Assessment guidelines developed used the pseudo risk-based approach. This approach divided the platforms into risk categories (high risk, medium risk and low risk). Besides that, it also considers the ‘failure consequence’ of the platform. This has three main components which are environmental loss, monetary loss and injuries/safety related loss.

During this time, the O&G industry also strongly increased its capabilities by developing necessary technologies in order to gain the required confidence in the reliability of assessment practice. It led to an improved understanding of platform behavior in the harsh offshore environment and a gradual ability to better explain observed in-service performance [5].

During the 1980s, which is the modern-RP2A era, Amoco pioneered assessment engineering for their Southern North Sea (SNS) platform fleet and their Central North Sea (CNS) platform Montrose Alpha [5]. The methodologies that Amoco used were derived from other industries such as the railway and bridge industries because these three industries faced the same problem. The problem they faced was the fitness for purpose of aging structures.

For the SNS assessment, Amoco developed the metocean hind-cast technology. This was a major breakthrough because hind-cast technology was able to back predict the maximum wave height from measured environmental and climatic data. Also in the same period Assessment, Inspection and Maintenance (AIM) Joint Industry Projects (JIP) were conducted for a variety of operators as well as Minerals Management Service (MMS) [5]. The purpose of this project was to establish a framework for accessing and maintaining older platforms. These can be said to be the start of the SIM journey in the O&G industry. During the late 1980’s, MMS developed an inspection program and during the same period it was clearly evident that an API process was required for assessing the structural integrity of existing jacket platforms. It was agreed that the approach should be different from the design of new platforms and a new section was established which is the “API RP2A, Section 17 – Assessment of Existing Platforms” [6]. MMS [7] issued a Notice to Lessees (NTL) in August 2003, requiring GOM platform owners to assess their platforms to Section 17 requirements. Many predicted that API RP2A: Section 17 would solve all the assessment problems regarding offshore platforms. But this was not the case. Severe storms and hurricanes that hit the GOM severely tested the assessment process. In 1992 the hurricane Andrew occurred in the GOM (figure 2). After hurricane Andrew, significant findings were made from the application of integrity management and assessment engineering at that time. One of the findings was that all platforms that were damaged or failed were the early vintage platforms of pre-1980 era. Platforms designed to RP2A standards in this era or to other standards (Pre-RP2A) are known to have certain design deficiencies’, such as low decks, weak joints or poor framing configurations [5]. Platforms that were designed to modern RP2A standards [1] had no extensive damage or failures. Among Modern RP2A platforms, the only one that was damaged was found to have been caused by construction error, and not design deficiency.

In 2002 hurricane Lili damaged and destroyed several older platforms, something that had not been seen since Andrew. This changed again with hurricane Ivan (2004) and hurricanes Katrina and Rita in 2005 [8, 9], which resulted in largest number of destroyed and damaged platforms in the history of GOM.

Consequently the API subcommittee established a Task Group to develop a stand-alone Recommended Practice (RP) [6, 10] for the integrity management of fixed offshore structures. This new RP will include all the experience gained from many years of operational experience and technological developments. The main purpose of this RP is to provide guidance to owners, operators and engineers in the implementation and delivery of the SIM process [6, 10].

Studies on Structural Integrity management in UK was driven by many offshore installations in the North Sea reaching or exceeding their original anticipated design life and also many owners being relatively new and not following the recognized good practice [11].

Technological developments provided improved understanding of the strength of components especially the reserve strength provided by the redundancy and robustness of jacket structures [12]. System strength is not addressed in Codes and guidance documents. By testing and field observations have shown that system capacity is more than that indicated by the failure of the first component. The design of joints have changed from no gussets, to centerline gussets and tangential gussets, to overlap joints and finally to joint cans [3]. Conventional design assumed rigid joint behaviour. New software models the flexibility of joints and the associated load redistribution that occurs during platform collapse. This enables more accurate determination of the ultimate strength of the platforms. The framing configuration of the structure has significant influence on the operational costs and risk levels. Large scale testing of jacket frame structures has improved understanding of these influences [13]. Operating experience of platforms has shown that the number of occurrences of fatigue cracks is not as high as would be expected considering the conservatism in the fatigue design process and implicit conservatism in the S-N curves. Recent studies show that the principal cause of this is the flexibility of joint which can now be modeled. There has been a gradual change in the level of structural optimization due to the use computers and more efficient structural analysis methods. This means that older platform designs were more conservative compared to the guidelines at the time [3].

Reserve strength ratio (RSR) is a measure of the structure's ability to withstand loads in excess of those determined from platform's design. The RSR is defined as the ratio of the structure's ultimate strength to a reference level load [14, 15, and 16]. The ultimate strength of an offshore platform is usually evaluated using non-linear finite element analysis of a structural model, often called pushover or collapse analysis. This reserve strength can be used to maintain the platform in service beyond their intended service life. Knowledge from the analysis can also be used to determine the criticality of components within the structural system and also used to prioritize the inspection and repair schemes.

Reliability techniques can be used to optimize the use of resources for inspection. These methods complement the traditional approach and engineering judgment [17, 18]. They can incorporate past inspection knowledge to plan future inspections.

Structural Integrity Management In API And ISO

The SIM framework based on API and ISO [19] has four main aspects namely Data, Evaluation, Strategy and Program, discussed further in the following sections.

The most crucial aspect is the Data. Data population study is carried out during the early phase of the SIM process to determine the availability of data that an operator has. Based on experience from the SIMS project of PCSB and SCIENTIGE, data is the main issue because most operators are not aware of what data they have and where the data is being kept. This can be overcome with better communication between personnel from different departments and streamlining their data management, ensuring that data is easily available when it is needed and all the data are complete. Furthermore, having a data tracking system enables a person to track when the data is being given, where it is being send to and who the recipients of the data is. In the SIM framework, the data that is required from a platform has to be up to date. Information on the original design, fabrication and installation process, inspections, evaluations, structural assessment, Strengthening, Modification and Repair (SMR) works which all constitute parts of the SIM knowledge base is very important to have.

The evaluation process which is the 2nd part of the SIM framework is carried out to evaluate all the data received in the 1st part of the SIM framework. The evaluation process would establish the future strategy and programs for the platform. This is to ensure that the platform meets the objectives of SIM which is to ensure that the platform is fit for purpose. The evaluation process would result in an appropriate strategy for inspection, monitoring, and commissioning or decommissioning of a platform. The evaluation process is carried out throughout the life span of a platform. As long as there is new data that is being received by the operator, evaluation of the data has to be carried out using engineering knowledge to identify any problems on the platform and take appropriate actions to rectify it. Sometimes the availability of data is a problem for the operators. Most operators do not have adequate data about their platform. Inadequate data would impact the evaluation process because no data means no evaluation and this would result in a problem for operators. Without evaluation strategy and programs cannot be developed for the platform. Overall the SIM process would be affected. The evaluation of data is carried out using a risk matrix. The PCSB currently categorizes their platforms based on a RBI tool consisting of

149 elements or data that has to be completed so that a risk ranking can be identified for each platform operated by PCSB.

The third part of the SIM framework is the strategy. It is applied when the evaluation results are available. The SIM strategy will be based on the answers to the following questions:

What type of inspection should be done?
What are the benefits of the inspection strategy?
What are the factors in determining the inspection strategy?
How should the inspection be done?

These strategies will ensure that the platform meets the objectives of SIM which is to ensure that the platform is fit for purpose. A SIM strategy enables the operators to pre-plan all the management aspect of an inspection. Besides that the inspection cost can be reduced by accommodating a number of platforms at the same location at the same time and an advanced scope of work can be prepared and submitted to the consultant for review which in return can reduce the waiting time for the consultant feedbacks. Lastly, by having an inspection strategy, the integrity of the platform can be preserved because it would undergo periodic evaluation to check whether it meets its fitness for purpose.

The Program represents the execution of the detailed scope of work and should be conducted to complete the activities defined in the SIM strategy. The Program may include one or more of the following activities; routine above water inspections, baseline inspections, routine underwater inspections, special inspections and Strengthening, Modification and/or Repair (SMR) activities. To complete the SIM process all data collected during the SIM Program should be incorporated back into the SIM data management framework. Consistency, accuracy and completeness of inspection records are important since these data form an integral part of the SIM framework.

It can be summarized that SIM is an important tool for an oil and gas operator to have. Although SIM is used in the GOM and North Sea, it has not yet been used in Malaysia.

PTS [20] covers only assessment of structures using static analysis and non-linear analysis whereas PTS [21] covers parts of strategy and program, both are not complete. It talks about risk based assessment but does not give the RISK MATRIX. Also regarding program, it is not giving the different levels of inspection. It also doesn't give the duration between inspections for different risks. Furthermore, there is no SIM framework with respect to Malaysian conditions such as platform data, age, risk, types of facilities etc.

Therefore it would be good if a SIM manual for Malaysia fixed offshore platform is developed. The manual should meet the objective of SIM which is to make sure a structure is fit-for-purpose during its design life and sometimes longer. This SIM manual for fixed offshore structure would be helpful to all the operators in this country.

Structural Integrity Management in Malaysia

Operators such as Shell, Exxon Mobil and Talisman have their own SIMS method in ensuring the fitness for purpose of their platforms. PCSB has a standalone system in managing their assets called the Asset Integrity Management System (AIMS). AIMS is an integrated management system that uses knowledge to manage the risk associated with physical assets. AIMS guide the organization into making and executing the decisions regarding the assets during each step of the asset's life cycle. AIMS is subjective because it covers a broad spectrum of assets like structural, topsides, equipment, and other non-structural assets.

PCSB has a Risk Based Inspection (RBI) program. This RBI program categorizes a platform based on its risk of failure. It uses risk as a basis to give priority to types of inspection and inspection intervals. The higher the risk of a platform to failure, the higher is the priority of the platform to be inspected and assessed. This is because RBI gives priority to higher risk platforms compared to lower risk platforms when setting up inspection and maintenance intervals. A risk matrix is developed based on the defined parameters. The two parameters are Likelihood of failure and Consequence of failure. An example of a risk matrix is shown in table 1. These parameters are scored and have different weight factors. The consequence and likelihood categories are arranged such that the highest risk ranking is toward the upper right-hand corner. The lowest risk items fall into category A1 and the highest risk items fall into category E5.

TABLE 1 RISK CATEGORIZATION MATRIX USED BY PCSB

Likelihood	A	B	C	D	E
5	M	H	H	VH	VH
4	L	M	H	H	VH
3	L	L	M	H	H
2	VL	L	L	M	H
1	VL	VL	L	L	M
	Consequence				

Currently, PCSB is developing a Structural Integrity Management System (SIMS) for their 175 offshore platforms. A transparent Structural Integrity Management System (SIMS) is essential to manage the on-going existing fixed offshore structures:

i. To manage on-going integrity over their life cycle.
ii. To identify and re-dress any long term degradation.
iii. To identify and prioritize the required structural integrity activities.
iv. To optimize the activities and resources required to manage the structural integrity.
v. To provide a basis on the conformance of structural integrity with all legislative requirement

III. RESULTS OF STUDY

Recommendations for SIM in Malaysia

To improve the SIM strategy in Malaysia, there is a need for an efficient way of handling data of each platform that PCSB operates. These can be done by having a document index that monitors the movement of data in the organization. The document index should include elements such as the platform name, the field in which it is located, its risk ranking, age of platform, types of facilities and data available about the platform. In the document index all the data that is available about the platform will be marked as available (√) and data that is not available will be acknowledged as not available (NA). The document index will also record the report number and the date of its publication. This is to ensure that all the data that is available is thoroughly audited and any data gaps can be identified quickly so that further action can be taken to address it. Appendix 1 shows the document index sheet.

Figure 3 shows summary of different categories of platforms in Malaysia. Figure 4 shows the latest region wise summary of age of platforms in Malaysia O&G industry. Figure 5 shows the latest region wise summary of different types of platforms in Malaysia O&G industry. More details are reported in [22].

Having a standalone PTS - SIM would greatly enhance the capabilities of PCSB in managing its offshore structures. This PTS-SIM would include all the data needed by PCSB, the RBI to evaluate the data and the strategy and programs that are relevant with the results of the evaluation. The standalone PTS-SIM would provide PCSB with:

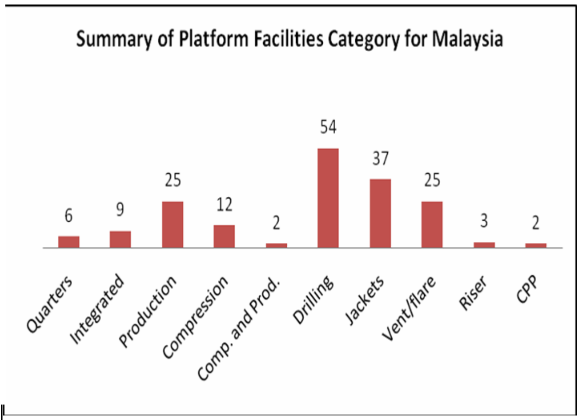


Fig. 3: Summary of Platform Facilties for Malaysia

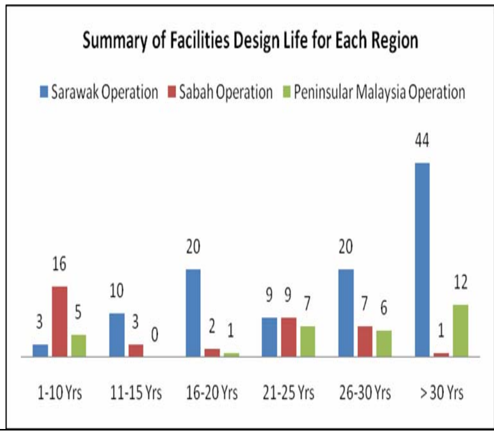


Fig. 4: Summary of Facilities Design Life for Each Region

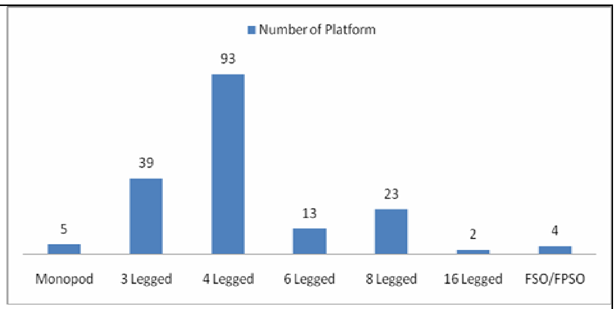


Fig. 5: Summary of Type of Platform Facilities for each region in Malaysia

1. Recommended Practice for Structural Integrity Management (SIM).
2. Guidance on Risk Based Inspection (RBI).
3. Guidance on risk understanding.
4. Efficient Data Management

Case Study of SIM of SMG-A

This case study was carried out on SMG-A platform located in the Semarang Field offshore Sabah. The six leg fixed Gas Compression Platform was installed on 1/1/1983 and is still active. It has exceeded its design life of 25 years. Therefore an effective SIM process is needed to ensure that SMG-A is still fit for purpose.

Data

Generic Details Of Smg-A

SMG-A with deck weight 1361 MT and jacket height of 10.4 m is installed in water depth of 10.1 m. The air gap is 5.0 m which is above the recommended minimum value of 1.5 m by PTS for all its platforms. The deck elevation for SMG-A is 12.2 m. SMG-A uses K-framing for both its longitudinal and transverse frames. Its base length is 33.5 m and base width 18.3 m. The details are shown in Table 2.

TABLE II GENERIC DETAILS OF SMG-A

Generic Details	
Water depth	10.1 m
Jacket Height	10.4 m
Air Gap	5.0 m
Deck Elevation	12.2 m
Long framing	K
Tran framing	K
# of bays	2
# of legs	6
# of piles	6
# of leg piles	6
# of skirt piles	0
Grouted Piles	No
Jacket weight	NA
Deck weight	1361 MT
Pile weight	NA
Base length	33.5 m
Base width	18.3 m

Operational Details Of Smg-A

SMG-A is an unmanned platform. However, it has a quarter's capacity for 3 people, meant for inspection and maintenance staff. SMG-A has 3 caissons, 0 conductors and 7 riser guards. SMG-A has one crane on its platform, one boat landing and no helipad. Its corrosion protection is through the sacrificial anodes. These details are given in table 3.

From its commissioning in 1983, SMG-A has undergone 2 underwater inspections (UI), done in 1994 and 2005. The data for UI in 1994 is not available. This data is essential because it can be considered as a baseline UI. The more favorable condition would be that an UI should have been carried out in 1983. This is because a baseline underwater inspection provides the as-installed platform condition which is a benchmark for the future SIM of the platform, especially if any potential damage occurred during installation. A baseline inspection should be conducted before the implementation of risk-based inspection (RBI) planning for the platform.

TABLE III OPERATIONAL DETAILS OF SMG-A

Operational details	
Manned	Yes
Shore distance	NA
Quarters capacity	3
# of slots	NA
# of caisson	3
# of conductors	0
# of Risers	7
Max cond. Dia.	NA
# of decks	NA
# of cranes	1
Max crane size	NA
Boat landing	Yes
Helipad	No
CP type	SA
Oil Prod	NA
Gas Prod	NA

Platform Inspection Data Of Smg-A

Figure 6 shows the North view of SMG-A platform.

Fig. 6 Row 3 (A1-B3) Platform North View

The minimum scope of work should consist of the following, unless the information is available from the design and installation records:

- A visual survey of the platform for structural damage, from the mud line to top of jacket.
- A visual survey to verify the presence and integrity of the sacrificial anodes.
- A visual survey to confirm of the number of installed appurtenances and their integrity.
- Confirmation of the as-installed platform orientation.
- Measurement of the as-installed platform level.

The scope of work of the UI carried out in 2005 is explained below:

Inspection Level: The inspection for UI 2005 is API Level 2. A Level 2 survey consists of general underwater visual inspection. It is done to detect the presence of any or all of the following: Excessive corrosion, Scour and seafloor instability etc., Design or construction deficiencies, Presence of debris, and Excessive marine growth. Detection of significant structural damage during a Level 2 survey is the basis for initiation of a Level 3 survey. The Level 3 survey, if required, should be conducted as soon as conditions permit.

General Visual Inspections: The jacket comprises of forty three members. Six members were inspected and no damage, deformation or other anomaly was found.

Splash zone Inspection: Twenty members of the jacket (six jacket legs and fourteen vertical diagonal members (VDM)) pass through the air and water interface. Inspection was completed on two jacket legs and five vertical diagonal members. No areas of coating breakdown were observed on the members that were inspected. No anomalies were reported during this inspection

Base level Survey: The gap between the underside of the bottom level horizontal members and the seabed was estimated using divers. Scour measurement at the base level is the vertical separation between each horizontal member and the seabed. This distance was estimated at both ends and at the centre of each face; which was at A3-B3 Face. The measurements for Face A3-A2-A1 were taken at leg A3 and A2. Measurements for the other two faces were not taken. No exposed pile was observed during the inspection.

Anode inspection: Twenty seven anodes were found on the Jacket Structure. Only four anodes were inspected and the depletion rate ranged between 20%-60%. No anomalies were reported for this inspection.

Cathodic Potential Survey: Thirty Nine contact Cathodic Potential measurements were obtained on jacket nodes, risers and riser clamps. Air divers were utilized to obtain the contact CP measurements. The measurements ranged between (-) 659mV to (-) 1068mV.

Marine growth (MG) survey: A MG survey was carried out by air divers on Leg A3 and B3. Circumferential measurements were obtained from MSL to EL (-) 10m in 5 meters increments. On Leg A3, the MG was most dense at EL (-) 5m down to EL (-) 10m; measured as 84.36mm thick. Whereas on Leg B3, the MG was most dense at EL (-) 10m; measured as 100.38mm thick. The MG consisted of barnacles, clams, sponges, hydroids, soft and hard corals.

Seabed Debris: Twelve items of debris were noted during the seabed debris survey. The twelve items were mostly metallic debris consisting of cut-off pipe section, scaffolding poles and grating.

Anomaly Summary: The following anomalies were found :

1. Low CP measurements of (-) 659mV and (-) 660mV were reported on riser no. 7.

2. The boat landing located at row 3 had missing gratings at lower stage of boat landing, and the top 3 grating steps of the stairway between the two stages of the boat landing.

Evaluation

Platform Risk Ranking

PCSB categorizes its platform based on the Platform risk ranking tool. The SIM process is associated with the RBI tool because the higher the risk the platform possesses, the higher the need for a SIM process to be carried out on the platform. Risk can be defined as [23]:

Risk = Consequence of failure x Likelihood of failure

After a risk value has been assigned to a platform, a risk matrix is developed to give a clearer picture of the risk of the platform for people. PCSB does this by using a 5 by 5 risk matrix (table 1).

The likelihood of structural collapse of a platform is assessed from two factors namely:

1. Platform strength or capacity.
2. Extreme loading the platform is exposed to.

The likelihood of failure categorization system identifies the characteristics of platforms that affects its structural strength and loads. The likelihood of failure of a platform would increase if there is an indication that there are factors attributing to the deterioration of platform strength or not up to current design practice. Besides that, if there are factors indicating that extreme platform loads may increase in frequency or severity, the likelihood of failure of the platform would also increase.

The consequence of failure has three main components. They are:

1. Environmental loss
2. Business loss
3. Injuries and safety related loss

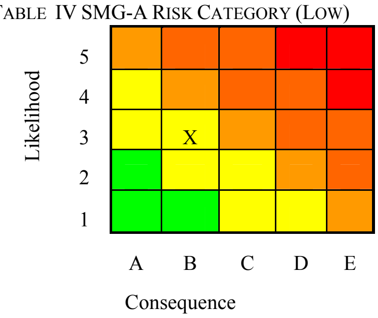
These components are calculated based on monetary losses to the operator. This three component monetary losses is summed up to come out with the overall result consequence.

For SMG-A, the result from the UI done in 2005 was applied on SIM system, and the following scores were obtained:

Likelihood Score	: 320
Consequence Value	: 32.34
RSR	: 3.24
Likelihood of Failure	: 3
Consequence of Failure	: B
Platform Risk	: Low (3B)

From table 4, it is observed that SMG-A is a low risk platform. The characteristic of a low risk platform is that it has low likelihood of failure and low consequence of failure categories. Since SMG-A has low likelihood of failure; it is unlikely to fail during the design event. This implies that there is sufficient reserve strength considering the platform's present condition, including all modifications and known damage, against the 100-year design load. The platform would remain undamaged during the design event. SMG-A can also be described as robust and tolerant to damage.

TABLE IV SMG-A RISK CATEGORY (LOW)



Furthermore, SMG-A has a low consequence of failure. A platform has a low consequence of failure when the production can be shut-in during design events, the wells contain subsurface safety valves and oil storage is limited. These platforms may support production departing from the platform and low volume infield pipelines.

It is possible that some older, larger platforms with more wells, more production equipment and in deeper water that is nearing the end of their useful life have a similar consequence of failure and can be considered low consequence. It has to be remembered that SMG-A is an old platform that has been in operation since 1983 and therefore the findings in this study is consistent with the expected result.

Strategy

For SMG-A, the next inspection to be done is a Risk Based Level 3 UI in the year 2015. This is because according to API recommended practices and guidelines, SMG-A is a low risk platform; the appropriate inspection interval is 11 years or greater (Table 5).

TABLE 5: RISK BASED INSPECTION PROGRAM

Risk Category	Inspection Interval Ranges
High	3-years to 5-years
Medium	6-years to 10-years
Low	11-years or greater

Notes:

a) The timing for the first underwater periodic inspection should be determined from the date of platform installation or when the baseline inspection was completed.

b) Risk-based intervals should be adjusted to ensure uninterrupted cathodic protection of the platform. This should be based on data evaluation from prior inspections.

In addition to the risk based approach for arriving at a SIM strategy, there is another method namely the consequence based inspection program (Table 6). The consequence-based inspection program provides a predefined in-service inspection program should the Owner/Operator choose not to implement SIM. Consequence based inspection program states that for Level 3 inspection, concerning low risk platforms, the interval is also more than 10 years.

Therefore, the most appropriate time to do a Level 3 UI for SMG-A would be in the year 2015. A Level 3 survey consists of an underwater visual inspection of pre-selected areas and based on the results of the Level 2 survey, areas of known or suspected damage. Such areas should be sufficiently cleaned of marine growth to permit thorough inspection.

TABLE VI CONSEQUENCE BASED INSPECTION PROGRAM

	Consequence Categorization		
	Low A-3/L-3	**Medium A-2/L-2**	**High A-1/L-1**
Interval (Years)		**10**	**6**
Level III			
Visual Corrosion Survey	**X**[3]	**X**[3]	**X**
Flooded Member Detection		**X**	**X**
Weld/Joint Close Visual		**X**	**X**

Detection of significant structural damage during a Level 3 survey should become the basis for initiation of a Level 4 survey where visual inspection alone cannot determine the extent of damage. The Level 4 survey, if required, should be conducted as soon as conditions permit.

IV. DISCUSSION OF RESULTS

The case study showed a gap in the inspection history of SMG-A after the installation process of SMG-A. After platform was installed in 1983, a baseline inspection should have been carried out in 1984. The future inspections data/results can be compared with this baseline inspection data.

The absence of the baseline data for SMG-A can be due to the following reasons

- The baseline inspection was carried out but the data was not found by PCSB
- A baseline inspection was carried out but during the platform operations handover the data was not given by the previous operators to PCSB
- No baseline inspection was done on SMG-A.

V. CONCLUSIONS

The following conclusions are obtained from the study:

i. For any operator, the benefit of having a SIM strategy is that it would be able to protect the life safety of offshore personnel, protect the environment, protect business assets, and protect the company and industry reputation. A systematic SIM strategy would ensure the continued fitness-for-purpose of offshore structures. The SIM process has evolved over the last 25 years in the GOM due to hurricanes and extreme weather conditions. Therefore this SIM process is able to provide the industry a means to ensure the continued safe and reliable operation of fixed offshore platforms around the world and specifically in Malaysia.

ii. The data for SMG-A platform is scattered and missing. Besides that, the inspection history of SMG-A showed that it had underwater inspections in 1994 and 2005. Only inspection data for 2005 is available therefore a comparison between these inspections cannot be done. A gap in the inspection program was found on SMG-A. The future program for SMG-A platform is that it has to undergo a level 3 underwater inspection in year 2015 based on API RP2A-WSD Section 17 recommendations.

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