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Preventive Maintenance: Some Operations and Technology Related Practices at a Malaysian Oil and Gas Firm

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ABSTRACT

The effectiveness of a maintenance management system can be measured by the way a function has achieved its intended objectives and generally evaluated based on the quality of the product or service provided, from the perspective of the user. The issues of high casualties in terms of personnel, millions of dollars in losses due to the unexpected shutdown of operations, environmental threats and the impact on the country's income should be addressed. Malaysian Oil and Gas Firm's maintenance system efficiency practices, technology availability, the selection of suppliers, the influence of preventive maintenance on company performance and the rationale for choosing PM for downstream activities were considered in the interest of the nation. The primary purpose of this study is to use a qualitative methodology to examine PM procedures at a Malaysian oil and gas firm. The oil and gas sector is commonly linked with high-risk, cutting-edge technology projects that can have devastating economic and ecological effects if anything goes wrong. The study utilized the semi-structured interview with 10 identified oil and gas maintenance management personnels such as Managers, Supervisors and Staffs who are attached to Maintenance Department as the 'gatekeepers' as they are the one who are directly involved directly in maintenance management activities as well as preparing the reports and data with regards oil and gas companies maintenance management system used for the study. The result from the study stated that the personnel involved in maintenance activities appreciate the practices utilized however with the new methods introduced, the study also proposed, appropriate maintenance implementation as well as the involvement of several parties in aspects of planning and formulating maintenance policy up to the implementation stage in the oil and gas operators' operation. The study can provide significant implications for theoretical, methodology and management involvement in terms of preventive maintenance contribution to organizational performance. This study analysed the issue raised in the implementation of preventative maintenance, specifically in Turnaround Maintenance in oil and gas company.

1. Introduction

The most significant source of energy in the world has always been oil since the mid-1950s [1]. The combination O&G supplies more than half of the world's energy requirements [2]. According to

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United Nations Development Programme (UNDP), oil and gas accounts for 57% of the world fuel consumption.

The products or by-products associated with oil have modernized the society across the globe, supplying energy to industry sectors and provide fuel for transportation purposes such as carrying people and goods for the well-being of human and also the nation [3]. Asad *et al.,* [4] further stated that O&G industries play a vital role in fast-tracking the world's economy. Although "renewable" and "sustainable" energy being introduced in conjunction with the technology advancement, none of it could contribute the same amount of energy as what can be provided by the O&G energy [5]. Employment opportunities are another significant contribution of the O&G industry to the global marketplace [6].

In Malaysia, Shell – a foreign-owned company discovered the oil well in Miri, Sarawak, on Canada Hill in 1910 [7]. "Miri No. 1" or now known as "The Grand Oil Lady" was spudded on 10 August 1910 [8]. According to Malaysia Productivity Corporation [9], there was no other drilling was carried out in Borneo or Peninsular Malaysia prior to the 1950s.

Petroleum activities increased sharply during the late 1960s with the development of offshore field in Borneo and Peninsular with Shell as the main player followed by Esso, Mobil Aquitaine, Oceanic and Teiseki. These foreign companies were given the exclusive rights to explore and produce oil products by the state governments in return for royalties and taxes [9]. As a result of the economic nationalism advocated in New Economic Policy (NEP), Petronas was established in 1974 pursuant to the Companies Act of 1965.

The industry in Malaysia regarding O&G industry is unique as Petronas, an acronym for Petroliam Nasional Berhad. Petronas is a Malaysian vertically integrated oil and gas company that was founded on 17 August 1974 [10]. The facility is the exclusive property of the Government of Malaysia, which is responsible for all of Malaysia's oil and gas resources [11]. Petronas acts as both the regulators as well as an operator in the oil and gas industry in Malaysia. Companies involved in O&G industry need to comply with Petronas' rules and regulations if they wish to operate in the O&G industry in Malaysia [12]. The license to explore and produce granted to the foreign companies by the state government previously were ceased to effect with the passing of the Petroleum Development Act in 1974 [9].

Petronas grants the right to explore and produce oil and gas to foreign companies under a Production Sharing Contract (PSC) [13]. The PSC Contractor has to provide all the financing requirements and must bear all risks related to exploration, development and production activities in return for a share of total production [10].

In relation to the importance of Petronas to the Malaysian as well as Malaysia's economy, Petronas, to ensure its operation do not suffer any setback or disruptions. Efforts have been made to prevent any accident; however, the risk of accident cannot be eliminated [14,15]. According to Department of Occupational Safety and Health [16], 73 fatalities and 214 permanent disabilities have been reported in year 2019 compared to 62 fatalities and 197 permanent disabilities recorded in 2018 at manufacturing and petroleum industries in Malaysia.

The latest technology advancement in oil and gas business requires innovative strategy were to minimize the risk factors [4]. A typical modern maintenance program is intended to optimize traditional maintenance practices, incorporate an assessment of equipment condition, historical information and other best practices [17]. Effective maintenance is dependent on basic task such as inspection, human senses, sensor and thresholds – the items focused on preventive maintenance approach [18,19].

The effectiveness of a maintenance management system can be gauged by observing how well its various parts carry out their functions and by considering the level of customer satisfaction with the end result. It is important to address worries about human casualties, economic losses from an

abrupt halt in operations, environmental harm, and the impact on the country's revenue. Additionally, Naidu *et al.,* [20] found that the pollution of river clearly an indication of environmental issue in their study about sewerage treatment plant effluent into the river. Ineffective maintenance management procedures, as discussed by Sinha [21] and Hari and Bhardwaj [22], can have serious consequences for a business, including threats to employee health and even fatalities. Supplier choice, the effect of PM on corporate performance, and the justification for PM in downstream operations are just a few of the factors that must be taken into account. The study tries to fill the research gap of practical-knowledge as suggested by Miles [23]. This gap highlights the professional behaviours or practices that either depart from the conclusions of research or are not covered by research.

This study provided a proper view of the maintenance management system in oil and gas industry and its relation to the contribution of wellbeing of the nation and human being and recommend improvement in the implementation of the system to reduce unnecessary expenditure by government agencies, oil and gas companies and to avoid work incidents for oil and gas workers as well. The study also addressed pertinent questions related to preventive maintenance in terms of practices, the reason why this became the preferred option for downstream operators, selection processes of third-party vendors and the impact on performance

2. Literature Review

2.1 The Evolution of Maintenance Strategies in Oil and Gas Industries

The maintenance management framework is an instrument to increase the share of the underlying asset level required to achieve the desired productivity at the expense of various levels of employment, equipment, and material use, subject to spending constraints [24,25]. The maintenance management system has shifted from simple accounting orders to more sophisticated performance measurement systems [26,27]. In oil and gas production facilities, for example, the tools associated with the industry are air switches, transmitters, valves and pumps. They have limited functions and usefulness. Maintenance of this equipment takes place when it fails completely. This kind of maintenance system is also known as primitive maintenance philosophy [19,28].

The unplanned or breakdown maintenance, which is regarded as a reactive maintenance program where the system is put into operation until it is shut down due to the system failure before the maintenance actions take place [29]. The industrial systems were operated up to the system failure, where the affected tools or equipment have been repaired or replaced, consistent with the popular maintenance philosophy "Fix it when it fails or breaks" [28].

The reactive maintenance lauds the principle of no action is taken to prevent system failures or to detect the onset of failures [27,30]. The maintenance method performed was on demand-based, generally due to major equipment breakdown or failure [28,29].

The period of during and after the World War II, the advancement of innovation and scientific technology were introduced due to the growing interest in the creation, individuals made many different types of maintenance, which are much cheaper, for example, preventive maintenance. People of that period classified maintenance as a function of the production system [31]. Periodic, planned and preventive maintenance were introduced during this time [32]. The evolution of maintenance definition detailed in the Figure 1.

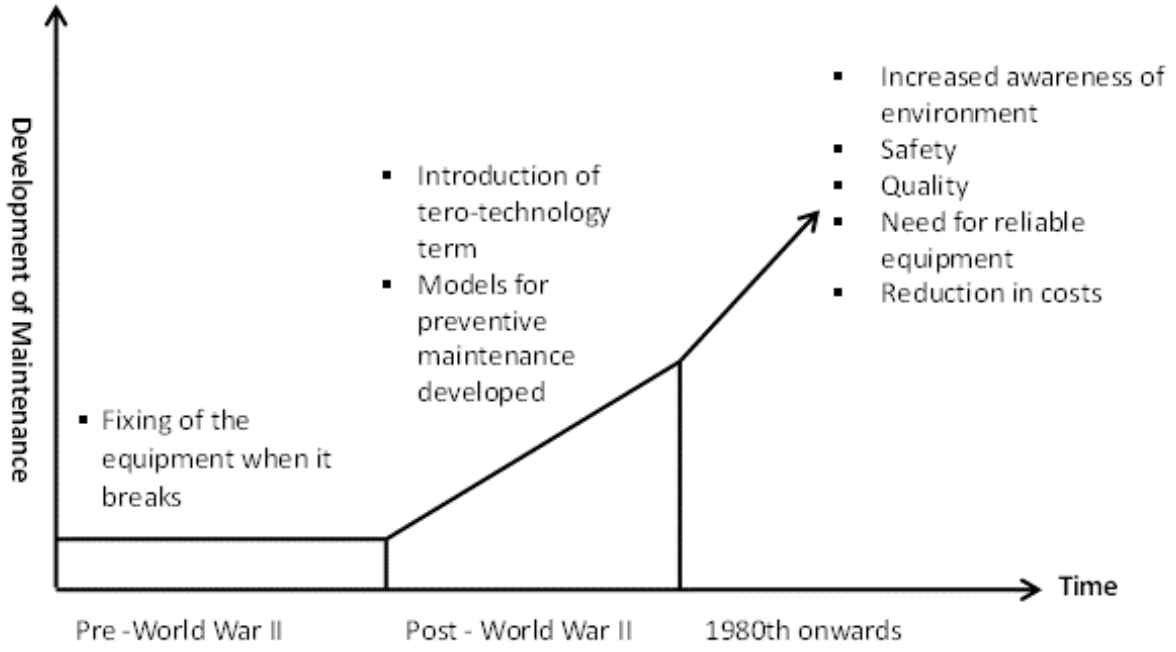

Fig. 1. History of maintenance

2.2 Maintenance Management

Maintenance management refers to many other terms like maintenance systems, maintenance policies, maintenance methods, maintenance, models, maintenance techniques, the philosophies of maintenance and the practices of maintenance which are used on a regular basis by many researchers to represent the concept of maintenance [33,34]. In this regard, this study will use the term "practice" to describe maintenance systems, maintenance policies, maintenance methods, maintenance schemes, maintenance techniques and maintenance philosophies. Asset and equipment maintenance spans numerous industries. Maintenance will continue to be performed so long as there is machinery, assets, etc. Carbon emissions, for instance, must be kept below the legal limit for a port to be considered "green." [35].

In addition, maintenance management techniques experience many major processes of transformation in recent years. Nowadays, the development in maintenance practice has been aggravated by the development of complex manufacturing process, variety of product demanded, increased awareness of maintenance influence on environment issue, safety of operators, business profitability and product quality [36]. Hence, the maintenance concept forced into production operation to enhance the sustainability of a company. Table 1 showcases the advancement in maintenance policies that has been categorized as first, second, third and recent generation [37,38].

Table 1
Development of maintenance philosophies

Generation	Maintenance Philosophies
First Generation	▪ Fix when it broke
	▪ Basic and Routine maintenance
	▪ Corrective maintenance
Second Generation	▪ Planned Preventive maintenance
	▪ Time based maintenance
	▪ System for planning and controlling work
Third Generation	▪ Condition based maintenance
	▪ Reliability centered maintenance
	▪ Computer aided maintenance management and information system
	▪ Workforce multi-Skilling and teamworking
	▪ Proactive and strategies
Recent Generation	▪ Risk based inspection
	▪ Risk based maintenance
	▪ Risk based life assessment
	▪ Reliability centered maintenance
	▪ Condition based monitoring
	▪ Computer aided maintenance management and information system

Maintenance can be categorized into different classifications according to its actions [39]. Maintenance practices have been reviewed by many researchers to understand its influence on company competitive advantage. A sum of 135 various maintenance models have been discussed in 10 previous reviews conducted by Noble [40], Derek [41], Sherwin [42], Ismail [43], Garg and Deshmukh [44], Schokry [45], Gomez *et al.,* [46], FZE [47], Galan and Gomez [48], and Lundgren *et al.,* [49]. These ten important reviews of this maintenance model were selected to determine which maintenance model was more accepted by academics and practitioners than by others.

The review indicated that the most discussed maintenance models were Preventive Maintenance (PM); Corrective Maintenance (CM), Condition-Based Maintenance (CBM); Total Productive Maintenance (TPM); and Reliability-Centred Maintenance. This is due to these maintenance strategies were widely adopted in maintenance, research [50]. Therefore, scholars in maintenance management field concluded that the main maintenance practices in industrial sector can be divided into two, Preventive Maintenance (PM) and Corrective Maintenance (CM) [51].

CM will be performed once the operation or the manufacturing process cease its activity [52]. In relation to that, the productivity will decrease in addition to the increase in the cost of production. Therefore, CM normally will be applied to non-critical assets which do not involve significant economic problem with the firm [53]. Generally, certain equipment, machine or system already been identified in CM practice as the other maintenance approach will involve more cost [54,55].

Meanwhile, Preventive Maintenance (PM) approach is the periodic task performed on the equipment/system to prevent failure [24}, Li & Zhang [56]. Singh [57] and Gwangwava *et al.,* [58], stated that PM regarded as planned or scheduled maintenance activity that is fundamental in maintenance policy of any firm. PM strategies were proposed in the 1940s that requires engineers to perform certain maintenance action to reduce the probability of system failure or avoided any operation shutdown totally [59,60]. Gunckel *et al.,* [61] highlighted that PM primarily performed to avoid unplanned maintenance, which normally not only trigger higher downtime, costly repair, interruption to business operation, but also will cause catastrophic events related to the safety of the personnel and also the environment. Therefore, the PM should be properly planned based on time, usage, age or condition information [62].

Effective maintenance strategies depend on acquiring proper knowledge regarding the principles and practices of the maintenance management as well as the information which relates to the performance of specific facility/equipment/system [55]. Rastegari [63] and Carnero & Carcel-Carrasco [64] further stated that no one-size-fit-all maintenance strategy exists today to accommodate the ever-changing facility performance and conditions. Therefore, the maintenance strategy and practice need to be specifically designed to satisfy the unique requirements of a facility/system/asset. An effective strategy essentially needs to be dynamic and periodically updated to address the change in environment and circumstances [55]. Fail to do so will result in catastrophic events not only for the company, the personnel involved as well as the environment.

2.3 Effectiveness in Oil and Gas Maintenance Management

Maintenance is typically associated with usually uncertain and erratic events. It is highly dependent on human expertise and is generally more than just automation [65]. Without an adequate and systematic framework, it will be difficult to perform maintenance functions effectively [66].

The effectiveness of the maintenance system can be determined by the optimization of maintenance planning and scheduling [67]. The maintenance management, according to Jonsson [68] and [69], was a combining element such as strategy, people, organization, support mechanism, tools and techniques. The five elements should be linked together to establish an effective maintenance management strategy [70].

In addition, the effective maintenance system also correlated with the cause-effect diagram relating to elements such as labour, equipment, method and machine [71] along with data, policies, techniques, considerations and instrumentation/tools [67,72]. The efficiency of the Maintenance Management System (MMS) may also be associated with the incorporation of AI techniques in the form of fuzzy games, neural networks and so forth in maintenance modeling and decision making [73,74] in addition to the involvement of high human expertise [75].

The effective maintenance of equipment or system is well noted to be very vital in today's economic downturn due to the spreading of the pandemic COVID-19 particularly in capital-intensive industry such as oil and gas. Organizations should develop quality benchmarks to measure the current effectiveness of the maintenance management system, anticipate future performance, and use the data to understand where improvements can be made (Christiansen 2018). The maintenance metric identified to give qualitative and quantitative insight in tracking, improving and optimizing the maintenance operation are, 1) Planned maintenance percentage (PMP); 2) Overall Equipment Effectiveness (OEE); 3) Mean time to repair (MTTR); 4) Mean time between failure (MTBF); and 5) Preventive maintenance compliance (PMC) [76].

Preventive maintenance is still based on the same basic principles that make it successful and cost-effective. This kind of maintenance plan has the built-in benefits of making equipment more available and reducing working failures, which saves money on asset management and asset lifecycle costs. In managing the life of industrial assets and utilities such as the O&G industry, innovation and technology have changed significantly over time. Therefore, the study of maintenance practices for Malaysia oil and gas company was conducted in order to understand the relevancy of the strategy in keeping pace with the new landscape of O&G industry.

3. Materials and Methodology

The purpose of this study is to examine the effectiveness of the preventive maintenance management system in Malaysian oil and gas company. Therefore, this chapter describes the research design methodology as guidelines for the study, which includes research design, data collection, participant selection and data management methods, reliability and validity issues, key thinking, and data analysis strategies. According to Patton [77] and Skinner *et al.,* [78], there are no sample size rules in qualitative research. Because relevant respondents were chosen for the study rather than statistical samples, generalising reasoning allows the study to be a credential search [79,80]. According to Cresswell [81], only qualified respondents will supply credible information for the study. The respondents of this study were managers, engineers, and executives that able to provide information with regards to the study.

3.1 Research Design

The objective of the research plan is to provide an adequate framework for a study. A very important decision in the research design process is the choice to be made in terms of the research approach, as it determines how relevant information will be collected for a study [82]. This search will be conducted using a descriptive search methodology. According to Loeb *et al.,* [83], the definition of descriptive research methodology better describes situations. For example, this method is intended to address the statement of the research problem ‘what' research topics rather than ‘why'. The descriptive research approach is different than the analytic approach [84]. It is because a descriptive search method describes what it is when the analytical search method determines the cause and effect of a particular subject. As such, descriptive research was the most appropriate course of action for this research design as this basically involves analyzing the data collected, in terms of sharing demographic data and descriptions, approving, and explaining the results of the research. Adams & Cox [85] and Tag *et al.,* [86] stated that tthese questions have also been selected to provide an in-depth understanding. Creswell [87] further explained that qualitative research conducted as a result of the need for a complex and comprehensive overview of the issue. Based on this understanding, qualitative methods that applied in this study that includes.

i. Interview session with staff familiar with the maintenance process in accordance with the interview plan. Informal questionnaires with open-ended questions were used for this semi-structured interview.
ii. Direct observations were made that included all participants and non-participants, ethnographic study, video or any photo material which allowed researchers to document and understand the context in which activities and events occur.

The interview method served to understand the maintenance staff. Based on DiCicco-Bloom & Crabtree [88] and Van Looy [89], qualitative interviews can be divided into some unstructured, semi structured and structured categories. The study focused on unstructured and semi-structured data, as structured interviews typically yield quantitative data [90]. This study used a semi-structured interview based on the core study questions developed prior to the interview [89,91,92]. On the other hand, the interviewer must remain open and flexible so that he can delve into more detail in the respondent's [88]. According to Van Looy [89], and Qu and Dumay [92], considerable attention is required prior to, during and after the interview session with respect to the manner in what questions are asked and construed. A fundamental characteristic of human conversation that allows the

researcher to control the pace and determine the style of the question. This is how respondents are most likely to respond [93,94].

Qualitative studies typically also involved "participant observation" in which the researcher was an active participant in the study [95]. Observation is considered the best technique for obtaining first-hand information when interview participants are not in a position to explain the phenomenon sought [96]. “The researcher engaged in participant observation tries to learn what life is like for an ‘insider’ while remaining, inevitably, an ‘outsider’” [97]. The purpose of observing maintenance activities is to gain an understanding of the work process performed by maintenance personnel. This kind of research is aimed at gathering more reliable information. In other words, researchers can capture information on what participants are doing rather than what they say they are doing. The recording of information depends in large part on the situation of the search. Field notes are usually kept, and tape recorders and video recorders can sometimes be used. Regardless of how the information is stored, it is important to be detailed and design a system that allows easy retrieval of the information [98].

3.2 Interview Design

The study was based on questions arising from an understanding of the maintenance process and job description of maintenance workers in the oil and gas industry. Additionally, questions were worded differently, explanations were provided, and for some interviewees, some questions were omitted or added to the interview. This study utilized the interviewing process stated in a book titled *“Qualitative Research Methods: A Data Collector’s Field Guide”*, that was published in 2005 [97].

Interviewees were contacted by email to arrange an appointment. The researchers gave a brief explanation of the purpose of the study, the procedures of the study, and the expectations of the study participants including how long it takes to participate. This is essential to ensure that respondents can be assured that they are participating in the study on a voluntary basis and can withdraw from the study at any time. Respondents are also convinced that their privacy is protected and that they know the risks and benefits expected from the study. Figure 2 demonstrates the interview process for this study.

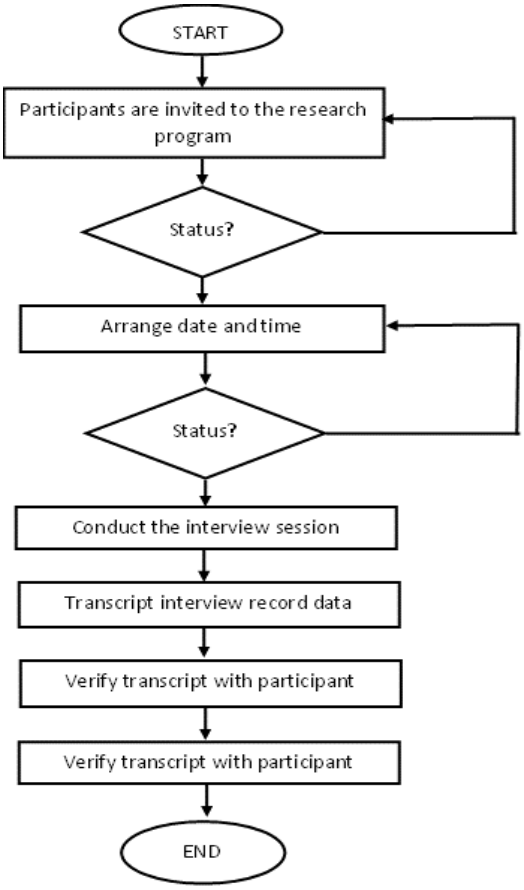

Fig. 2. Procedure for interview session

3.3 Observation Design

The obervation method in this qualitative study gave the researcher determined the respondents and record the required data based on what they observe. The resulting data reflect respondents' actual behaviour. Researchers get a clearer picture and greater situational awareness for their study. The researcher will thus be in a better position to formulate a suitable recommendation on the underlying phenomena of the study [27]. As it is in the interest of organizational processes, observation serves as the main tool to help document what is happening in that context. This is a valuable tool because

i. It provides first-hand access and information about complex social interactions and physical contexts;
ii. It provides persistent and systematic records of interactions and parameters;
iii. It can be contextually sensitive and environmentally valid [99-100];
iv. It uses a variety of techniques, generate different types of data and have the potential to apply them broadly in different contexts; and
v. It can be used to answer a variety of research questions [101,102].

The checklist for the observation task is as described in the Table 2.

Table 2
Observation checklist

No.	Description	Remarks
1.	Date and Time Observation	
2.	Type of Maintenance Activity	
3.	Type of Observation	
4.	Meeting Point / Location	
5.	Document Reference	
6.	Representative	
7.	Maintenance Person in Charge	
8.	Duration of Observation	
9.	Observation Status	
10.	Other Remarks	

In this study, researcher involved in the observing maintenance personnel and their selected vendors in their maintenance work activities/programmes. The researcher took field notes on the behaviour and activities of the personnel involved. Field notes formed files, whether they are unstructured or semi-structured. These data were saved in the Microsoft Word format and uploaded to Atlas.ti as core data for analysis.

4. Result & Discussion

The deliberative and explanatory approach to the results and the analysis which will be structured on the basis of the methods used. This means in the order in which the report was presented, which was interviews and observations with the staff concerned. In terms of research design, the goal of data collection was to look for answers to the RQ. This is an explanatory study of how preventive maintenance contributes to the company's competitiveness. The RQ developed for the study will be organized and put into a matrix to align with subsequent findings to provide a better flow of rationales and sequences by responding to all RQs.

4.1 Data Analysis Using Atlas.ti

All data from interviews and observations are uploaded to Atlas.ti. Quotations are developed and subsequently assigned coding. Codes are grouped as according to the themes, similar to the results using the manual process. Through the relationships of groups of networks being established and a pattern emerged. Subsequently, a new code of sustained competitive advantage is being created as the end results from the combination of the flows of all the networks.

4.2 Themes and Significant Statements

Three main themes are coded according to the research framework and the additional information required according to the comments of the Malaysian oil and gas company's maintenance management staff. The themes encoded in the Atlas.ti app are the preventive maintenance practices, strategy, third party vendor selection and the effect of preventive maintenance on the organization performance.

4.2.1 Preventive maintenance theme

The preventive maintenance practice theme has showcased the that the maintenance personnel involved in maintenance program/work/activities understood the practices used in the company. All respondents (100%) acknowledge the exact maintenance practice performed in the company. However, they were divided in terms of how the work-related problem can be mitigated. 60% stated the need for systems/tools/equipment review, meanwhile the other 40% mentioned about the need for preventive maintenance program.

"If we can detect something that can be dangerous or something that the machine is going to fail, we need to fix or upgrade immediately."

Respondent #3

"We are going to follow our own strategy, ECA (Equipment Criticality Assessment). We will identify the equipment that could have the most serious impact on the company's performance and take the necessary measures."

Respondent #4

"First of all, we have our main maintenance method, PPM which is Planned Preventive Maintenance. That way, we can avoid any problems as far as our commercial operations are concerned. No interruption so we need to detect a problem before it happens. Preventative maintenance provides us with this capability. "

Respondent #9

In relation to the good preventive maintenance measures, 60% of the respondents stated the zero downtime/shutdown is the main parameters. Another 30% mentioned about the reliability score and the balance highlighted the issue of knowledgeable and experience personnel. The various feedbacks originated from the different background and the formal and informal of maintenance knowledge accumulated.

4.2.2 Third-party vendor selection theme

In terms of the criteria for vendor selection, the feedback gathered were varied such as, 1) experience; 2) number of manpower; 3) manpower capability; 4) resources; 5) equipment; 6) quality of work; 7) vendor's rating; 8) respond time; and 9) statement-of-work (SOW). 80% stated experience is the key criteria for vendor selection, 60% mentioned the resources element of the vendor and 30% highlighted the need for a proper manpower.

"We will choose according to experience, performance and work quality."

Respondent #5

"Experience, labour, resources and vendor evaluation."

Respondent #6

"First, we will look at experience, followed by labour availability, and also their response time."

Respondent #7

The main criteria are the experience of the vendor. We must ensure that the selected vendor has relevant experience as the oil and gas industry, we have certain rules and regulation that we have to comply, so the vendor need to know all these things. We also choose vendors based on their turnaround time and the resources they have."

Respondent #8

The other important aspect of understanding the vendor selection process for the firm is whether awarding the contract under the lowest bidder's policy is practical. Responses indicate that 100% of respondents stated that the lowest bidder policy is not an appropriate choice. This is due to various reasons such as

i. need to fulfil scope of work;
ii. the requirement in providing efficient and effective work;
iii. provide safety and reliability;
iv. the work requires experience;
v. quality of work consideration;
vi. specific resources required;
vii. certain requirement or criteria of work that need to be performed.

4.2.3 The impact of preventive maintenance practice on organization performance

Theme 3 of the research related to the impact of preventive maintenance on organizational performance. Responses from study participants demonstrated that current maintenance practice has been successful in helping the organization to be in good condition from an operational and profitability point of view. In respect to the satisfaction of the current preventive maintenance program, all respondents reverted with their satisfaction.

"Yes, I am satisfied as we do not experience any major issue with regards to shut down, etc."

Respondent #1

"Yes, I am satisfied with our preventive maintenance program. Our reliability score is the evident of successful program that we put in place."

Respondent #2

Meanwhile, regarding the selection of maintenance projects due to budgetary constraints, all respondents stated that this is something that cannot be avoided. This still needs to happen at a later date. The work normally selected will be based on job ranking or priority.

"Based on priority. This one, we got the system. We create a system; we list all non-routine jobs that are not routine. As a result, maintenance work will be carried out on a priority basis. We choose the maintenance work based on the classification of those that must be performed first."

Respondent #2

"Yes. This is due to the task priority as well as the available resources. "

Respondent #3

In summary, the company's preventive maintenance practice enabled study respondents to plan and schedule efficient maintenance work. A longer-term objective is to switch to a more predictive maintenance model in conjunction with their overall maintenance activities.

Effective preventive maintenance is formulated from a specific knowledge of the characteristics of the materials used, established engineering principles, development and validation of information technology programs, and interaction with the existing domain and environment [103]. The integration and inclusion of maintenance knowledge in oil and gas operations maintenance processes and infrastructure lays the groundwork for a more holistic approach to ICT-based maintenance solutions [104]. Hence, the establishment of maintenance program planning as well as effective and efficient maintenance management system are extremely important for effective management of preventive maintenance.

In the context of managing third-party vendor, the business must have a clear understanding of how to deal with onshore and offshore vendor. Currently, the company's Vendor Management Division is responsible for evaluating, analyzing, contracting and categorizing vendors. However, the practice needs to be understood by all the parties involved. Best practice will be dependent upon ongoing monitoring, regular meetings to monitor performance, share information and encourage accountability [105,106].

5. Conclusion

Preventive is another term to safety and based on the current study, the researcher has come to the conclusion that safety is a top priority for the company. Preventive maintenance practice has been positively contributing to the good performance. Hence, this need to be continued and enhanced. This requires effective management not only during pandemic crises, but also during normal daily activities to ensure business continuity and preserve value [107,108]. The company continued its activities by taking advantage of digitization, technology and equipping its employees with the necessary digital skills and competences. New ways of working have created a safer and more efficient workplace that maintains a continuous supply of energy to meet the day-to-day needs of communities, businesses and partners [109]. In conclusion, preventive maintenance has been earmarked as the trade secret for the company under research. The practice ensured that the company’s operation was kept at its optimal level while protecting the national interests.

In addition, the findings were only from the respondents of one organization on preventive maintenance practice especially on the focus of turnaround maintenance towards sustaining competitive advantage in the context of that organization. Hence, the generalization on any other industry is not relevant and the findings cannot be applied to other countries as well. As for recommendations for future studies preventive maintenance capability can be used as a factor to have excellent performance in other industries as well. With regards to the semi-structured interview results, it is found that preventive maintenance capability can be used to measure relationships between the maintenance practice and the performance of the organization.

This study has made a significant contribution to the literature on preventive maintenance and its impact on organisational performance. This analysis is anticipated to be beneficial to Malaysian oil and gas operators and the O&G industry. Recommendations for future studies provide some suggestions for enhancing this study. This study's insightful ideas will hopefully enable companies to attain greater levels of excellence.

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