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Resources-Based Maintenance: Evaluation Of Maintenance Effectiveness On Oil And Gas Floating Terminal In Malaysia

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ABSTRACT

Maintenance effectiveness is an important feature to ensure equipments in facilities are safe and effective. In offshore Oil and Gas (O&G) industry, safety and effectiveness of equipments are very meaningful to workers, managers, and stakeholders. There are series of O&G incidents, which are relating to deficiency of maintenance management, for instance; Deepwater Horizon (2010), Texas City Refinery (2005), and Piper Alpha (1988). Nowadays, there are many methodologies of maintenance management systems, which have been developed such as Total Productive Maintenance (TPM), Reliability Centre Management (RCM), and Strategic Maintenance Management (SMM). However, reports on measurement of maintenance effectiveness for Floating, Production, Storage and Offloading (FPSO) and Floating, Storage and Offloading (FSO) are yet scarcely available. Therefore, maintenance at FPSO & FSO needs a Resources-based maintenance (RBM) as a framework to measure the maintenance effectiveness based on demographic of FPSO and FSO. This paper describes the framework of RBM and discusses the result of FPSO and FSO maintenance effectiveness. The expected outcome of measurement maintenance effectiveness in FPSO and FSO could provide some direction for future research.

INTRODUCTION

Oil and Gas (O&G) industry is receiving much attention from safety and organisational performance experts and researchers alike. Generally, most of the discussion issue in O&G is related to major hazard, disaster and Health, Safety and Environment (HSE) where focus in statistic (Health And Safety Executive1, 2010; Health And Safety Executive2, 2010; OGP[1], 2010; OGP[2], 2010; MMS1, 2002; WorksafeBC, 2010), risk (Vinnem, 2010; Dey *et al.*, 2004), accident (Patin, 2010; Cutler, 2010; Baram, 2010), human factor (Sutherland & Cooper, 1991; Safari *et al.*, 2001; Parkes, 1993; MMS[1], 2002) and safety culture (Cox & Cheyne, 2000).

However, discussion in O&G maintenance management is very limited. The selected issue in maintenance O&G for this study is concerning about maintenance management, facility management and health, safety and environmental (HSE). Discussion in O&G maintenance management issues are about maintenance optimization (Okstad *et al*., 2010; Yin *et al*., 2009), maintenance performance measurement (Parida & Chattopadhyay, 2007; Parida, & Kumar, 2006), maintenance information system (Kans, 2009; Labib, 1998) and maintenance policies (Coetzee, 1999).

Facility management issue in offshore O&G has been discussed in aging facility (Casselman, 2010; Ersdal & Selnes, 2010; Norwegian Oil Industry Association, 2008), worker experience (Burke *et al*., 2009), worker qualification (Burke *et al*., 2009) and FPSO (Okstad *et al*., 2010; Trenholm, 2006; Brown, 2004; Llyod's Register, 2003). Discussions in HSE issue are root causes of major disaster (Cutler, 2010), next major disaster prevention (Baram, 2010; OGP[2], 2004) and impact of incident to HSE (Cutler, 2010). Works from National Offshore Petroleum Safety Authority (NOPSA) from Australia found that lower personal injury rates, less slip, trips and falls do not mean lower risk of accident and incident risk at offshore facility (Cutler, 2010). Therefore, the safety in O&G facility is still debatable since there are major incidents still happen recently for instance, deepwater horizons in Gulf of Mexico (GOM).

A Review Of Maintenance Effectiveness Measurement:

Total Productive Maintenance (TPM) has been introduced in Japan in 1971 and successfully implemented at 51 manufacturing factories between 1971 until 1982 (Nakajima, S., 1988). TPM works on maintaining ideal

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operating conditions and running equipment effectively to achieve maximum output (figure 1). In the production improvement TPM has emphasized in minimizing input (man, machine and material) and maximizing output (production, quality, cost, delivery, safety and morale). Then, the measurement elements are relating losses on; Availability, Performance efficiency and Rate of Quality (table 1).

Dr. Kaoru Ishikawa developed a causal diagram for Kawasaki Shipyard on 1968. The causal diagram also named as fishbone diagram, herringbone diagram, cause-and-effect, or Fishikawa. Typically, fishbone diagram is process to identify potential factors causing an overall effect. Fishbone has emphasized six cause categories called as 6M's (man, method, machine, material, measurement and mother nature or environment) for manufacturing sector in identifying causes during group brainstorming session(figure 2).

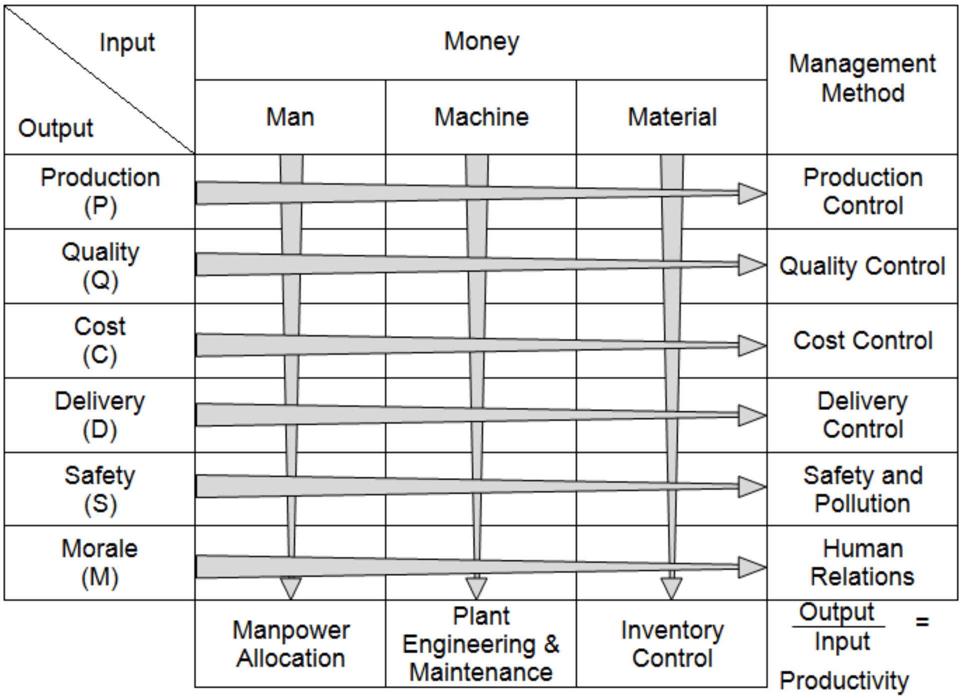

Fig. 1: Relationship between input and output in production activities (Nakajima, S., 1988).

Table 1: OEE measurement aspects and relating losses (Nakajima, S., 1988).

Performance aspects	Availability	Performance efficiency	Rate of Quality
Relating losses	Equipment failure	Idling and minor stoppage losses	Defect and rework losses
	Set-up and adjustment losses	Reduced speed losses	Start-up losses

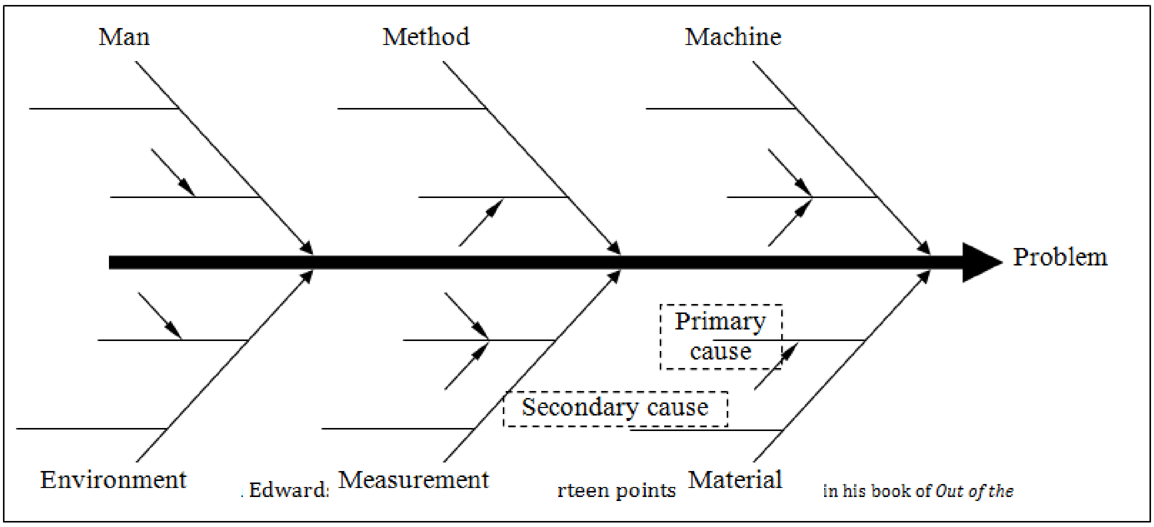

Fig. 2: Fishbone diagram with 6 M''s

Crisis in 1986. In transforming business effectiveness, these fourteen points have emphasized on;

1. Create constancy of purpose toward improvement of product and service.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on the basis of a price tag.
5. Improve constantly and forever the system of production and service.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations, and targets for the work force.
11. a. Eliminate work standards (quotas) on the factory floor

b. Eliminate management by objective.

12. a. Remove barriers that rob people in management and in engineering of their right to pride of workmanship.

b. Remove barriers that rob the hourly worker of his right to pride of workmanship.

13. Institute a vigorous program of education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation.

Stapelberg, R. F., (2009) in Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design have approached RAM in three definitions;

1. Reliability (Page 45),

a. Reliability prediction is estimation of the probability of successful system performance or operation.

b. Reliability assessment is estimation of the probability that an item of equipment will perform its intended function for a specified interval under stated conditions.

c. Reliability evaluation is determination of the frequency with which component failures occur over a specified period of time.

2. Availability (Page 298),

a. Availability prediction is a prognosis of systems operability and systems performance under conditions subject to various performance criteria;

b. Availability assessment is inferences of equipment usage with respect to downtime and maintenance;

c. Availability evaluation is measures of time that are subject to delays, particularly with respect to anticipated values of administrative and logistics downtime.

3. Maintainability analysis is result of prediction in engineering design stage, assessment by a well-defined program and evaluation by maintainability program plan. However, in maintenance perspective, maintainability is the probability that a failed item will be restored to an operational effective condition within a given period of time (Page 299).

Resources-Based Maintenance:

RBM is introduced in this paper for maintenance efficiency measurement in FPSO and FSO. Basic components of RBM are human resources, information technology (IT) resources, material resources, operational resources and management resources. The function of RBM is basing on idea of reliability, availability and maintainability (RAM) for maintenance operation against health, safety and environmental (figure 3). Components in RBM are considering idea of TPM's production improvement (Nakajima, S., 1988), Fishbone diagram (Dr. Kaoru Ishikawa), fourteen points for management (Dr. William Edwards Deming), and RAM (Stapelberg, R. F., 2009). However, components of cost and money are removed from RBM due to limitation of accessibility and confidentiality in Malaysian O&G Company. The evaluation of RBM is based on perception of worker on their experience and working condition at facility. The worker perception is preferred in this paper due to incident in Deepwater Horizon (2010). There is finding of 390 outstanding jobs during rig audit in seven months before the explosion. Olmos, J., (2010) reported that the worker was aware there were deficiencies in maintenance and safety aboard the rig, however they did not speak out due to fear of punishment from employer. Whenever, OG facility's maintenance met or exceeded government regulatory standards did not at all indicate that the facility was safe (Cutler, J., 2010 & Olmos, J., 2010).

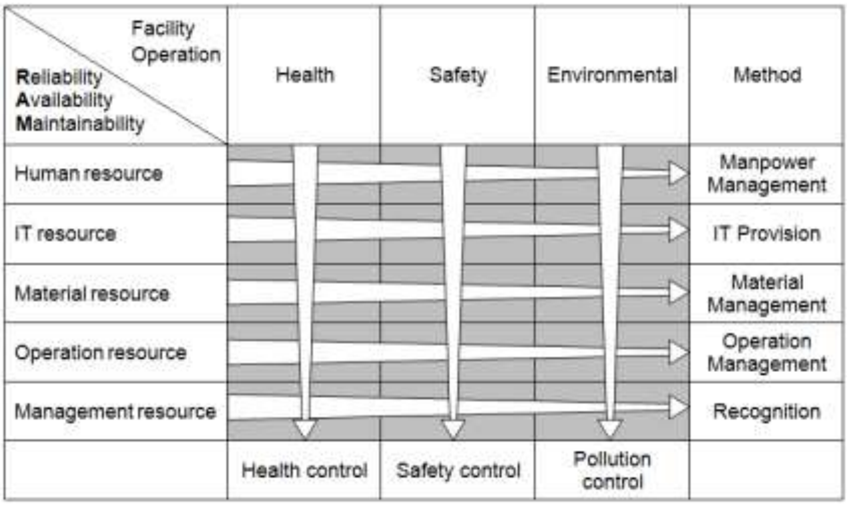

Fig. 3: Resource-based Maintenance is adaptation of TPM's Relationship between input and output in production activities.

A conceptual diagram has been developed and proposed in this study to achieve the objective (figure 4). The structure of the study consists in three sections: 1). Independent variable, 2). First dependent variable, and 3). Second dependent variable. Facility demographic consisting worker profile (e.g. age, qualification and experience), age of facility and type of facility (e.g. FPSO and FSO) are factors to be considered in measuring maintenance performance of offshore O&G.

Facility demography as independent variable section is considered, namely as: 1) Staff profile (age, qualification and experience), 2) Type of facility (FPSO or FSO), and 3) Age of facility. In first dependent variable section, Resources-based maintenance effectiveness will consider: 1) Human resources (Strength of organization, training development and staff performance), 2) Information technology resources (Computerised Maintenance Management System (CMMS) application, internet access and computer access), 3) Material resources (Working tools, spare part and manual instruction book), 4) Operation resources (Machinery and equipment of fire fighting essential, life saving essential, production essential and non essential), and 5) Management resources (maintenance objective, working procedure, technical support and legislation compliance). As such, the second dependent variables, namely, Facility operation performance is consisting of: 1) Health performance (Post-Traumatic Stress Disorder (PTSD)), 2) Safety performance (Accident and incident), and 3) Environmental performance (Hydrocarbon release).

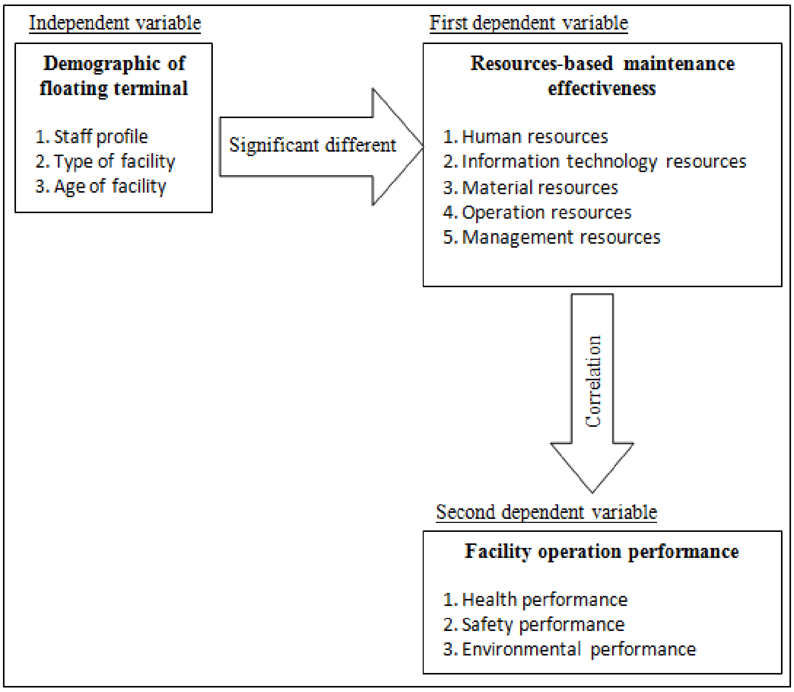

Fig. 4: Conceptual diagram

Methodology Of The Case Study:

There are two floating terminal facilities involved in this study and namely as; FSO “A” and FSO “C”. A self-completed questionnaire survey is applied to collect the data. The option of answering in the survey is using six-point Likert scale. The six options approach in Likert scale is to avoid respondent from taking neutral point as a noncommittal answer (Bradley, 2010). Six-point Likert scale for satisfaction are; “very good”,” good”, “slightly good”, “slightly poor”, “poor” and “very poor”. While respondent’s experiences and case of activity repetition is assessed by; “very often”, “often”, “slightly often”, “slightly rare”, “rare”, “very rare”.

Populations of offshore workers onboard FSO who involved in operation and maintenance is about 14 persons on each location. Therefore, total of population in maintenance for this study will be 24 persons from two units of FSO. According to Krejcie & Morgan (1970), if number of population is 25, then the sampling will be 24. Therefore, 24 samplings were taken from the population. In pilot test survey, 11 respondents as ideal numbers have been taken from 24 samplings.

Statistical Package for the Social Sciences (SPSS) software is used for information data analysing. Statistical analyses to be used are Descriptive statistics, ANOVA One Way, T-Test and Correlation. Likert scale for measuring components of resources-based maintenance is valued with number. The value in Likert scale are; Very good=5, Good=4, Slightly good=3, Slightly poor=2, Poor=1, Very poor=0, and Very often=0, Often=1, Slightly often=2, Slightly rare=3, Rare=4, Very rare=5. The total of value in measuring components of resources-based maintenance will be used to answer first objective of the study. Performance level of facility operation performance is total of its components measurement. The significant difference between facility demographic and maintenance effectiveness are evaluated by using ANOVA one way analysis. The third objective is to determine, by using spearmen’s correlation, linkage of maintenance effectiveness and facility operation performance.

Data Analysis And Finding:

Pilot test has been conducted on FSO “A” and involving 11 respondents (Table 2).

Case Processing Summary:

Table 2: Respondent of pilot test.

		N	%
Cases	Valid	11	100.0
	Excluded[a]	0	.0
	Total	11	100.0

a. Listwise deletion based on all variables in the procedure.

The Cronbach's Alpha test has been carried out in three clusters; Resources-based Maintenance (Table 3), Maintenance practice (Table 4) and Repetitions (Table 5). Questionnaire in Cluster of resources-based maintenance contains; Staying longer, Manpower retention, Training development, CMMS applications, Computer access, Internet access, Working tools, Spare parts supply, Manual instruction book, Maintenance objective, Compliance of legislation, and Outsourcing for expertise.

Reliability Statistics of Resources—based Maintenance:

Table 3: Cluster of Resources-based Maintenance.

Cronbach's Alpha	N of Items
0.881	12

Cluster of maintenance practice contains questionnaires pertaining to reliability, availability and maintainability of each component; Emergency fire pump, Fire pipe line, Life boat, Power generation unit, Sea water cooling pipe line, Cargo oil pimp system, Cargo pipe line and Air condition system.

Reliability Statistics of Maintenance Practice:

Table 4: Cluster of Maintenance Practice.

Cronbach's Alpha	N of Items
0.887	24

For questionnaire in cluster of repetitions are; Problem of machinery and equipment, Emergency maintenance, Corrective maintenance, Preventive maintenance, Occurrence of incident, Disturbance thoughts or images, Fear feeling, Occurrence of hydrocarbon release.

Reliability Statistics of Repetitions:

Table 5: Cluster of Repetitions.

Cronbach's Alpha	N of Items
0.746	8

Actual survey on FSO "A" and FSO "C" has begun in August, 2011 until January, 2012. The first objective to gain Maintenance effectiveness level is obtained by Mean analysis. Score segregation or points of effectiveness level are in table 6.

Table 6: Score segregation or points of effectiveness level.

Mean	Level
1.00 until 2.66	Poor
2.67 until 4.33	Moderate
4.34 until 6.00	Effective

Generally, score of maintenance effectiveness in RBM of both facilities is "Excellent", except for component "IT resources" and "material resources" score 4.10 points and 4.16 points, respectively. Respondents gave high score to other components by 4.45 points until 4.80 points.

The significant differences between facility demographic and maintenance effectiveness are obtained by T-test analysis and Anova one-way. T-test analysis has shown the fact that there are significant differences between type of facility and management resources, operational resources –production essential and operational resources –non production essential (Table 6). A value of 'p' for three factors is between 0.005 until 0.04, and lowers than preferred significant level at 0.05 (5%).

Table 6: T-test analysis of significant difference maintenance effectiveness

Factor	Type of facility	n	Mean	SD	t-value	p
Management resources	FSO Abu	16	4.50	.53	-3.21	0.005*
	FSO Cendor	7	4.95	.13		
Operational resources3 - Production essential	FSO Abu	16	4.40	.41	-2.90	0.009*
	FSO Cendor	7	4.86	.13		
Operational resources4 - Non production essential	FSO Abu	16	4.58	.49	2.09	0.049*
	FSO Cendor	7	4.14	.38		

** significant as at 0.05*

Analysis of Anova one-way is applied for significant difference between factors of RBM and facility demographic (age of facility, age group, academic qualification and working experience in O&G). This can be referred to Table 7. The result has shown that there are significant differences between age of facility and material resources, operational resources – production essential, operational resources – non production essential and management resources. Probability of 'f' value for these factors is between 0.01 until 0.04, and preferred significant level is 0.05 (5%). Probability of 'f' value is very low and it showed tendency towards significant. There are no significant differences between other factors of facility demography and other factors of RBM due to probability of 'f' value is very low, which is higher than significant level 0.05.

Table 7: Anova one-way analysis of significant difference maintenance effectiveness

		Age of facility	Mean	Std. Deviation	F	f prob.
1.	Material resources	0-5 years old	3.92	.67	3.275	.05*
		6-10 years old	4.58	.17		
		above 20 years old	4.33	.00		
2.	Operational resources3 - Production essential	0-5 years old	4.35	0.46	4.649	.022*
		6-10 years old	4.54	0.14		
		above 20 years old	4.86	0.13		
3.	Operational resources4 - Non production essential	0-5 years old	4.47	0.52	3.911	.037*
		6-10 years old	4.92	0.17		
		above 20 years old	4.14	0.38		
4.	Management resources	0-5 years old	4.36	0.52	5.668	.011*
		6-10 years old	4.92	0.32		
		above 20 years old	4.95	0.13		

** significant as at 0.05*

Analysis of Least Significant Difference (LSD) is used to find the most significant group's factor between age of facility and material resources, operational resources – production essential, operational resources – non production essential and management resources. Result of LSD analysis of significant difference between material resources and age of facility shows a significant difference between mean of respondent from group 0 ~ 5 years old facilities and 6 ~ 10 years old facilities (Table 8). Result of LSD analysis of significant difference between operational resources – production essential and age of facility shows a significant difference between mean of respondent from group 0 ~ 5 years old facilities and above 20 years old facilities (Table 9). Result of LSD analysis of significant difference between operational resources – non production essential and age of facility shows a significant difference between mean of respondent from group 6 ~ 10 years old facilities and above 20 years old facilities (Table 10). Result of LSD analysis of significant difference between management resources and age of facility shows a significant difference between mean of respondent from 0 ~ 5 years old facilities with group 6 ~ 10 years old facilities and above 20 years old facilities (Table 11).

Table 8: Analysis of LSD between material resources and age of facility

Group	Mean	0-5 years old	6-10 years old	above 20 years old
0-5 years old	3.92	-		
6-10 years old	4.58	*0.03**	-	
above 20 years old	4.33	*ns*	*ns*	-

** significant as at 0.05*
ns – not significant

Table 9: Analysis of LSD between operational resources – production essential and age of facility

Group	Mean	0-5 years old	6-10 years old	above 20 years old
0-5 years old	4.35	-		
6-10 years old	4.54	*ns*	-	
above 20 years old	4.86	.006*	*ns*	-

** significant as at 0.05*
ns – not significant

Table 10: Analysis of LSD between operational resources – non-production essential and age of facility

Group	Mean	0-5 years old	6-10 years old	above 20 years old
0-5 years old	4.47	-		
6-10 years old	4.92	*ns*	-	
above 20 years old	4.14	*ns*	.011*	-

** significant as at 0.05*
ns – not significant

Table 11: Analysis of LSD between management resources and age of facility

Group	Mean	0-5 years old	6-10 years old	above 20 years old
0-5 years old	4.36	-		
6-10 years old	4.92	*0.03**	-	
above 20 years old	4.95	*0.007**	*ns*	-

** significant as at 0.05*
ns – not significant

Pearson analysis is applied to find correlation between maintenance effectiveness and facility operation performance (FOP). Result of analysis has shown that the strength of correlation between overall FOP and operation resources is average, where the value of 'r' is 0.62 and significant level at 0.002 (table 12). Correlation between other RBM's component and overall FOP are average and lower, as the value of 'r' is 0.59 until -0.9 and significant level at 0.003 and 0.83. According to Chua, Y. P.,(2006), strength of correlation is average when value of 'r' is between 0.51 and 0.70 (table 13).

Table 12: Pearson Analysis of correlation between components of RBM and facility operation performance (FOP).

Resourse-based maintenance	Overall of facility operation performance		
	correlation value (*rs*)	Significant value (*p*)	Relationship level
Operational resource	.62	0.002**	Average

*** significant as at p<0.01*
** significant as at p<0.05*

Table 13: Strength of correlation coefficient value (Chua, Y. P.,2006)

Size of Correlation coefficient (r)	Strength of Correlation
0.91 ~ 1.00 or -0.91 ~ -1.00	Very Strong
0.71 ~ 0.90 or -0.71 ~ -0.90	Strong
0.51 ~ 0.70 or -0.51 ~ -0.70	Average
0.31 ~ 0.50 or -0.31 ~ -0.50	Weak
0.01 ~ 0.30 or -0.01 ~ -0.30	Very Weak
0.00	No Correlation

Analysis result of correlation strength between health performances in FOP and operation resources and RBM overall is average, where the value of 'r' is 0.64 and 0.61, and significant level at 0.001 and 0.002 (table 14). Correlation between other RBM's component and health performances are average and lower, as the value of 'r' is 0.57 until -0.7 and significant level at 0.002 until 0.79.

Table 14: Pearson Analysis of correlation between components of RBM and health performance in FOP.

Resourse-based maintenance	Overall of facility operation performance		
	correlation value (*rs*)	Significant value (*p*)	Relationship level
Operational resource	.64	0.001**	Average
Resources-based maintenance overall	.61	0.002**	Average

*** significant as at p<0.01*
** significant as at p<0.05*

Table 14: Pearson Analysis of correlation between components of RBM and health performance in FOP.

Conclusion:

Based on the RBM measurement, maintenance effectiveness at two Oil and Gas floating facility in Malaysia, namely as FSO ‘A’ and FSO ‘B,’ is at excellent level. The excellent result is based on perception of offshore workers and until today there is no major incident recorded for FSO & FPSO in Malaysia.

Discussion:

This paper is associated with from widely publicised industrial major disaster, i.e. Deepwater Horizon 2010. These incidents are reported involves maintenance cause and chain reaction mainly came from human, facility, management and financial. While, the impacts to safety, environment, life, properties, reputation and financial are very high to pay.

The series of these incidents happened all over the world, regardless of how advanced the country is. Furthermore, there are incidents that happen to companies which are applying latest technology, and highly publicised method, technique and philosophy (Coetzee, 1999). The argument then is not how good they are towards O&G industry, but how applicable it is to all practitioners.

The important element of this study is to understand O&G maintenance operation in Malaysia, especially in floating terminal. There are numbers of procedure, manual, and requirement for offshore staff to comply in practising maintenance job. Most of the O&G companies have been putting a lot of resources and effort for the safe and efficient operation performance. However, their impacts on performance in regards to efficiency, safety, and environment are yet questionable due to factor in maintenance. Good understanding in O&G maintenance in Malaysia results in good selection of maintenance strategy approach to be applied in O&G operation.

Studying floating terminal facility in Malaysia opens up an opportunity for Operation and Maintenance’s company to be more competitive and sustainable. Accident and incident disasters in O&G Malaysia can be prevented by understanding better perspectives and approaches in maintenance management.

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REFERENCES

Aoudia, M., O. Belmokhtar, & G. Zwingelstein, 2008. Economic impact of maintenance management ineffectiveness of an oil and gas company. Journal of Quality in Maintenance Engineering, 14(3): 237-261.

Baram, M., 2010. Preventing Accidents in Offshore Oil and Gas Operations: The U.S. Approach and Some Contrasting Features of the Norwegian Approach. Boston University. School of Law Working Paper No. 09-43. March 19, 2011, from http://ssrn.com/abstract=1705812

Brown, R.R., 2004. Lessons Learned: An Exploration Of Floating, Production, Storage, And Offloading Electrical Systems And Installation Issues. IEEE Industry Applications Magazine, Mar/Apr 2004, WWW.IEEE.Org/IAS.

British Petroleum, (September 8, 2010). Deepwater Horizon: Accident Investigation Report. British Petroleum, Retrieved January 22, 2011, from http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/incident_response/STAGING/local_assets/downloads_pdfs/Deepwater_Horizon_Accident_Investigation_Report.pdf

Burke, R.J., S.B. Matthiesen, S. Einarsen, L. Fiskenbaum, & V. Soiland, 2009. Gender differences in work experiences and satisfactions of Norwegian oil rig workers. Gender in Management: An International Journal, 23(2), pp. 137-147, DOI: 10.1108/17542410810858330

Casselman, B., (December 16, 2010), Aging oil rigs, pipelines expose Gulf of Mexico to accidents, Wall Street Journal. Retrieved February 14, 2011, from http://online.wsj.com/article/SB40001424052748704584804575644463302701660.html

Chua, Y.P., 2006. Asas Statistik Penyelidikan Buku 2, McGraw-Hill, Malaysia.

Cox, S.J. & A.J.T. Cheyne, 2000. Assessing Safety Culture in Offshore Environments. Safety Science, 34: 111-129

Coetzee, J.L., 1999. A holistic approach to the maintenance “problem”. Journal of Quality in Maintenance Engineering. 5(3): 276-280. DOI: 10.1108/13552519910282737

Cutler, J., 2010. Offshore Petroleum Safety: Priorities for 2010 and Beyond, NOPSA, CITI Investor Symposium, Retrieved January 19, 2011, from http://www.nopsa.gov.au/presentation/Presentation%20-%20Jane%20Cutler%20-%20CITI%20Investor%20Symposium%20-%2023-11-2010.pdf

Dey, P.K., S.O. Ogunlana, & S. Naksuksakul, 2004. Risk-based maintenance. model for offshore oil and gas pipelines, Journal of Quality in Maintenance Engineering, 10(3): 169-183. DOI 10.1108/13552510410553226.

Dickey, H., V. Watson, & A. Zangelidis, 2009. Job Satisfaction and Quit Intentions of Offshore Workers in the UK North Sea Oil and Gas Industry. Munich Personal RePEc Archive (MPRA), Paper no. 18666, Retrieved January 22, 2011, from http://mpra.ub.uni-muenchen.de/18666/1/MPRA_paper_18666.pdf

Ersdal, G. & P.O. Selnes, 2010. Life Extension of Aging Petroleum Production Facilities Offshore. SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production. DOI 10.2118/127134-MS.

Ghoneim, S.A. & H.M.A. Fahmy, 2002. Specification of the DRM and the Time for Preventive Maintenance for an Aging Resource. Electronics, Circuits and Systems, 2002. 9th International Conference on, 1, pp. 205-208. DOI: 10.1109/ICECS.2002.1045369

Health and Safety Executive1, 2010. Offshore safety statistics bulletin 2009/10, Retrieved January 19, 2011, from http://www.hse.gov.uk/offshore/statistics/stat0910.htm

Health and Safety Executive2, 2010. Offshore Injury, Ill Health and Incident Statistics 2009/2010, HID Statistics Report HSR 2010- 1, Retrieved January 22, 2011, from http://www.hse.gov.uk/offshore/statistics/hsr0910.pdf.

Kans, M., 2009. The advancement of maintenance information technology, Journal of Quality in Maintenance Engineering, 15(1): 5-16, DOI: 10.1108/13552510910943859

Krejcie, R.V. & D.W. Morgan, 1970. Determining Sample Size For Research Activities. Educational And Psychological Measurement, 30: 607-610.

Kumar, J. & T. Markeset, 2007. Development of performance-based service strategies for the oil and gas industry. Journal of Business & Industrial Marketing, 22(4): 272-280. DOI: 10.1108/08858620710754531

Llyod’s Register, 2003. FPSO Inspection Repair & Maintenance. UKOOA, Retrieved January 26, 2011, from http://www.oilandgasuk.co.uk/cmsfiles/modules/publications/pdfs/OP033.pdf

Minerals Management Service[1], (September, 2002). OCS Oil Spill Fact, U.S. Department of the Interior Minerals Management Service, Retrieved January 22, 2011, from http://www.boemre.gov/stats/PDFs/2002OilSpillFacts.pdf

Minerals Management Service[2], (April 8-10, 2002). Demystifying Human Factors: Practical solutions to reduce incidents and improve safety, quality and reliability. 2nd International Workshop On Human Factors In Offshore Operations. Retrieved January 22, 2011, from http://www.boemre.gov/tarprojects/401/401aa.pdf.

Nakajima, S., 1988. Introduction of TPM: Total Productive Maintenance, Cambridge, Massachusetts: Productivity Press.

Norwegian Oil Industry Association. (June, 2008). Recommended guidelines for the assessment and documentation of service life extension of facilities. Norwegian Oil Industry Association (OLF). Retrieved Oct 3, 2010, from www.olf.no

OGP[1], 2010. Safety performance indicators – 2009 data. International Association of Oil & Gas Producers, Retrieved January 20, 2011, from report 439 at http://www.ogp.org.uk.

OGP[2], 2010. Major Accidents. International Association of Oil & Gas Producers, Retrieved January 20, 2011, from report 434-17 at http://www.ogp.org.uk.

OGP[3], 2004. Preventing the next major incident, International Association of Oil & Gas Producers, Retrieved January 20, 2011, from report 363 at http://www.ogp.org.uk.

Okstad, E., J. Vatn, & R. Bye, 2010. Maintenance management and optimization of FPSOs. Reliability, Risk, and Safety, Taylor & Francis Group, London, Volume 1, 2, 3, pp. 591-598. DOI: 10.1201/9780203859759.ch81.

Olmos, J., 2010. Deepwater Horizon workers knew of problems before explosion, Retrieved October 14, 2010, from http://www.wsws.org/articles/2010/jul2010/nytr-j23.shtml

Parida, A. & G. Chattopadhyay, 2007. Development of a multi-criteria hierarchical framework for maintenance performance measurement (MPM),Journal of Quality in Maintenance Engineering, 13(3): 241-258, DOI: 10.1108/13552510710780276

Parida, A. & U. Kumar, 2006. Maintenance Performance Measurement (MPM): issue and challenges. Journal of Quality in Maintenance Engineering, 12(3): 239-251. DOI: 10.1108/13552510610685084.

Parkes, K.R., 1993. Human Factors, Shift Work, And Alertness In The Offshore Oil Industry. Health and Safety Executive - Offshore Technology Report. London: HMSO

Patin, S., 2010. Accidents during the offshore oil and gas development, Offshoreenvironment.com, Retrieved January 19, 2010, from http://www.offshore-environment.com/accidents.html

Safari, B., D. Ilsley, & J. Healy, 2001. The Human Factor: A benchmark of worker attitude to Health, Safety and Environment in the Australian Oil and Gas Industry 1999-2000. National Institute of Labour Studies, Flinders University, Adelaide, Australia, Retrieved February 14, 2011, from http://nils.flinders.edu.au/assets/publications/benchmarkreport.pdf

Stapelberg, R.F., 2009. Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design. Springer: London, DOI : 10.1007/978-1-84800-175-6

Sutherland, V.J. & C.L. Cooper, 1991. Personality, Stress and Accident involvement in the Offshore Oil and Gas Industry. Personality and Individual Differences, 12(2): 195-204.

Trenholm, B., 2006. Lesson Learned: Knowledge gained during the development and operation of a floating production storage and offloading offshore platform. IEEE Industry Applications Magazine, pp: 22-27. www.ieee.org/ias

Vinnem, J.E., 2010. Risk indicators for major hazards on offshore installations, Safety Science, 48, pp. 770–787. DOI:10.1016/j.ssci.2010.02.015.

Worksafe, B.C., 2010. Statistics for Oil & Gas Industry, WorkSafeBC, Retrieved January 19, 2011, From http://www2.worksafebc.com/Portals/Petroleum/Statistics.asp.

Yin, Q.S., P. Valls, & R. Smith, 2009. Minimizing Life Cycle Cost by Incorporating Reliability, Availability and Maintainability (RAM) into Process Design. Proceedings of the 1st Annual Gas Processing Symposium, 10-12 January, 2009, Doha, Qatar.