International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 5 Issue 7 ǁ July. 2017 ǁ PP. 25-31

Risk Based Underwater Inspection (RBUI) For Existing Fixed Platforms In Indonesia

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Abstract *For existing fixed platforms in Indonesian waters, a method to determine underwater inspection basedon the risk level is needed as an alternative for the conventional time-based underwater inspection. This paper discusses the development of Risk Based Underwater Inspection (RBUI) for Indonesian fixed offshore platforms by adopting the inspection scope from API RP 2A-WSD and API RP 2SIM. The risk will be determined based on the calculated Consequence of Failure (CoF) and Probability of Failure (PoF), and then it will be converted into a relevant inspection interval according to the references. In addition, it had also been discovered that the minimum fatigue of a platform that is shorter than the intended design life appeared to be the major problem of the Indonesian existing platforms. Therefore, this condition would be taken into consideration as a factor to override the preliminary inspection interval plan. Sample of 10 platform data located in Indonesian waters were used for RBUI analysis in this paper.*
Keywords*: RBUI, Indonesia, fixed platform.*

I. INTRODUCTION

Offshore platforms in Indonesia had been existed from early 1970s. Based on Indonesia's government regulation, each platform should be inspected at time-based inspection interval. The interval is annually for minor inspection, biannually for major inspection, and 4-years for complete inspection. As the offshore industry growing and development of regulation, there are new trends in the inspection of offshore platforms. New regulation drives and give recommendations that inspection interval is based on the risk level of offshore platform, not by conventional time-based inspection. As well as the development of new standards of risk based underwater inspection (RBUI) inside API RP 2SIM, Indonesia is looking forward to applying this inspection methodology by proposing the methodology based on the standards and adapted to Indonesia's offshore characteristic.

The primary purpose of developing and implementing RBUI approach is to prioritize the inspection, maintenance and repair (IMR) plan by simultaneously considering the owner/operator risks from environmental perspective and from a business standpoint and appropriately target the IMR resources according to the risk level. Later, every platform inspection interval plan could be different from one another, depending on the RBUI result for each individual platform.

II. APPROACH AND METHODOLOGY

Risk is expressed as Probability of failure multiplied by consequence of failure. To conduct RBUI, there are several steps to be performed. In the beginning, the platform needs to be evaluated is selected. After that, the relevant data and information are collected to identify hazards, and other consideration that is needed to conduct risk analysis. Then, risk factor will be categorized in terms of both CoF and PoF to determine the risk matrix. CoF consist of consequence factors expressing the negative impact of the events and PoF consist of probability of occurrence that reflecting various damage mechanisms and possible threat to the structure. The RBUI process is shown in Figure 1.

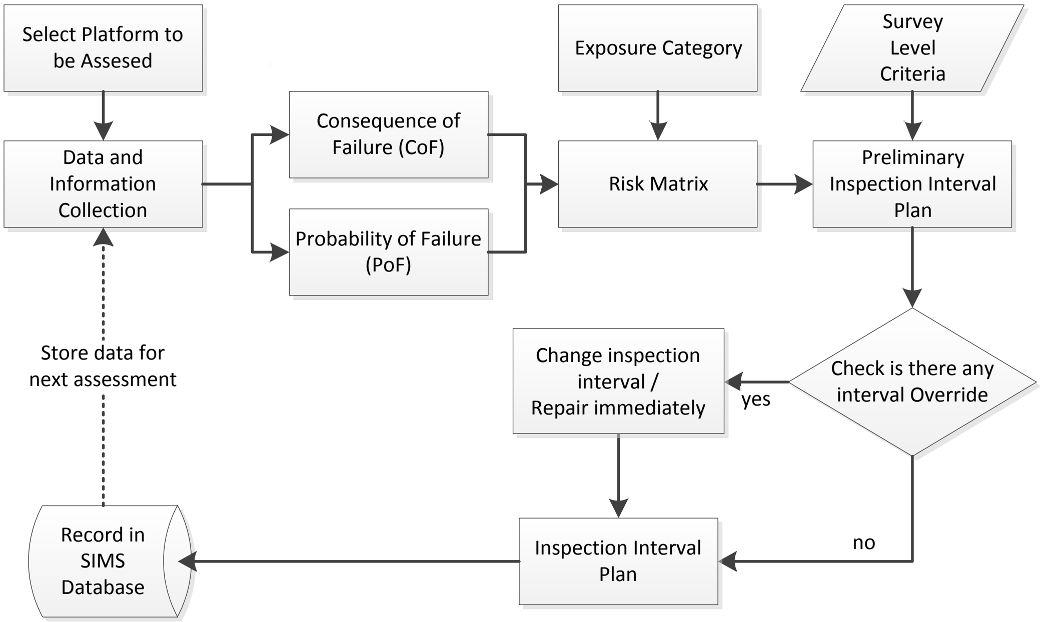


Figure 1: Flowchart of RBUI process

III. DATA AND INDORMATION

RBUI process is determined by using available data and information. Data and information detail consist of Platforms production data, Platforms hub and dependencies, Platforms characteristic data (design and requalification data) and Platforms condition data (inspection result). Sample of platform data is shown in Table 1.

Table 1: Sample of Platform Characteristic and Inspection Data

No	Platform	Installed Year	Platform Type	Number of Legs	Bracing	Last Inspection		
						Level I	Level II	Level III
1	A	1975	Process	8	/	2014	2013	2011
2	B	1975	Service	4	K	2014	2013	2011
3	C	1975	Support	3	/	2014	2013	2011
4	D	1975	Support	3	/	2014	2013	2011
5	E	1975	Wellhead	4	/	2014	2013	2011
6	F	1975	Process	4	K	2014	2013	2011
7	G	1974	Support	3	/	2014	2013	2011
8	H	1975	Wellhead	4	/	2014	2013	2011
9	I	1987	Wellhead	4	/	2014	2013	2011
10	J	1984	Wellhead	4	/	2014	2013	2011

IV. RISK CRITERIA

The risk level of RBUI is determined based on Probability of Failure (PoF) and Consequence of Failure (CoF) parameters which have different weight factor (%) reflecting significance and frequency of occurrence

4.1 Probability of Failure

The PoF is determined by failure parameters associated with damage mechanism and threats to the platform. Failure parameters are factors that occur from characteristic and condition aspects. Each probability of failure factor contributes to the calculation in the form of scores which varies from 1 to 5 with score 5 being the highest score of probability of failure. Weightings of each PoF factor are added in the form of percentage (%) to differentiate one factor to another. The weightings are determined based on the significance of each PoF factor to the risk level with the total weighting for all PoF factor is 100%.

Characteristics factors are platform design that implies to the probability of occurring, while condition factors are inspection results that provide additional risk associated with the probability of failure. Characteristic factors consist of structural parameters that implies to the probability of failure. Characteristic factor consists of 5 major aspects as described below. The "platform present condition" rules are used to adjust the baseline PoF score to represent the present condition of the platform, i.e. any degradation of the structure during fabrication, installation or operation. The rules account for the severity of the detected damage and the possibility of the structure having undetected damage. The explanation of every probability of failure factors is given below. As explanation above, PoF scoring can be summarized as given in Table 2.

Table 2: Criteria for Probability of Failure

PoF Factors		Score Weighting (%)	Base Score				
			5	4	3	2	1
Characteristic Factors	Installed Year	5	Before 1970	-	1971-1979	-	After 1979
	Number of Leg	5	Monopod	Tripod	4 Legs	5-7 Legs	≥ 8 Legs
	Bracing Configuration	10	/	-	K	-	X
	Service Life to Design Life Ratio	10	≤ 1	1 – 2	2 – 5	5 – 10	> 10
	Platform Function	15	Process, Service, Living Quarters	-	Wellhead	-	Support
	RSR	25	≤ 1.6	1.6 – 1.9	1.9 – 2.2	2.2 – 2.5	> 2.5
Condition Factor	Marine Growth (inch)	5	> 5	4 – 5	3 – 4	2 – 3	≤ 2
	Scour (feet)	5	> 2	1.5 - 2	1 – 1.5	0.5 – 1	≤ 0.5
	Metal Loss (mm)	10	> 3	2.25 – 3	1.25 – 2.25	0.5 – 1.25	≤ 0.5
	Cathodic Protection	10	No Data or Never Been Inspected	More positive than - 750 mV	- 750 mV up to - 800 mV	- 800 mV up to - 850 mV	- 850 mV up to - 1100 mV

4.2 Consequence of Failure

CoF consist of safety, business and environment criteria are further determined by using a combination of subjective expert judgment and qualitative analysis of those losses associated with platform failure. In some oil companies, the CoF determination is taken from average of each criteria, but in this study, the CoF is determined by the maximum score from the three criteria. The CoF criteria can be summarized as a matrix inTable 3.

Table 3: Criteria for Consequence of Failure (CoF)

CoF Factors	Base Score				
	1	2	3	4	5
Safety	Unmanned	-	Normally Unmanned	-	Manned
Business	Production ≤ 500 BOEPD	Production 501 - 1000 BOEPD	Production 1001 - 1500 BOEPD	Production 1501 - 2500 BOEPD	Production > 2500 BOEPD
Environment	Production ≤ 500 BOPD	Production 501 - 1000 BOPD	Production 1001 - 1500 BOPD	Production 1501 – 2500 BOPD	Production > 2500 BOPD

Sample of PoF and CoF implementation is shown in Table 4.

Table 4: Sample of PoF and CoF Criteria Implementation

No	Platform ID	PoF Criteria														CoF Criteria				
		Characteristic Factor						Condition Factor				Total		Total Score	PoF Level	Criteria			Maximum Score	CoF Level
		Install Year	Leg	Brace	Fatigue	Function	RSR	Marine Growth	Scour	CP	Corrosion	Score	Weight			Environment	Business	Safety		
		5%	5%	10%	10%	15%	25%	5%	5%	10%	10%	100%	100%							
1	A	3	1	5	4	5	3	5	1	1	2	30	3.2	3.2	D	5	5	3	5	5
2	B	3	3	3	5	5	4	5	1	1	2	32	3.45	3.45	D	1	1	5	5	5
3	C	3	4	5	3	1	4	2	1	1	1	25	2.65	2.65	C	1	1	1	1	1
4	D	3	4	5	4	1	3	3	1	1	1	26	2.55	2.55	C	1	1	1	1	1
5	E	3	3	5	5	3	4	3	1	1	1	29	3.15	3.15	D	4	4	1	4	4
6	F	3	3	3	5	5	3	5	1	4	2	34	3.5	3.5	D	2	2	3	3	3
7	G	3	4	5	3	1	4	3	5	4	1	33	3.2	3.2	D	1	1	1	1	1
8	H	3	3	5	5	3	3	3	1	4	2	32	3.3	3.3	D	2	2	1	2	2
9	I	1	3	5	3	3	3	3	2	1	1	25	2.65	2.65	C	1	1	3	3	3
10	J	1	3	5	4	3	1	3	2	1	1	24	2.25	2.25	C	1	1	3	3	3

4.3 Risk Ranking

The term "risk" is used to differentiate one platform to another in terms of relative risk of risk based on each platform's property and inspection records that are summed in the form of probability and consequences of failure. Risk is obtained by corresponding the CoF and PoF for each platform in the risk matrix, which determines the level of risk that a certain platform is in.The level of risk of a certain platform is thereafter can be the basis of the inspection plan. Risk may be presented in a variety of ways to communicate the results of the analysis to decision- makers and inspection planners. One goal of the risk determination is to communicate the results in a common format that a variety of people can understand. A risk matrix may be helpful in accomplishing this goal

V. EXPOSURE CATEGORY

Existing platforms are categorized by their life-safety and consequence exposure to determine the criteria for fitness-for-purpose assessment and for developing the inspection strategies. Life safety should consider the maximum anticipated environmental event that would be expected to occur while personnel are on the platform. Categories for life-safety are S-1, S-2 and S-3. S-1 category means the platform is manned-non-evacuated, S-2 category is chosen if the platform is manned-evacuated and S-3 category is for unmanned platform. Categories for the consequences of failure are C-1, C-2 and C-3. C-1 category is related to high consequence of failure, C-2 category is for medium consequence of failure and the last C-3 category is for low consequence of failure. The exposure category matrix is given in Table 5.

Table 5: Exposure Category Matrix

Exposure Category Based on API				Adjusted Matrix					
Life Safety Category	Consequence Category			Life Safety Category	Consequence Category				
					5	4	3	2	1
	C1	C2	C3		C1		C2	C3	
S1	L-1	L-1	L-1	S1	L-1	L-1	L-1	L-1	L-1
S2	L-1	L-2	L-2	S2	L-1	L-1	L-2	L-2	L-2
S3	L-1	L-2	L-3	S3	L-1	L-1	L-2	L-3	L-3

VI. SURVEY LEVEL

To determine inspection interval. API recommendation is used as shown in Table 6. Survey level column represents of platform's inspection and verification performance. Survey level consists of 4 (four) categories depend on the inspection and verification level.

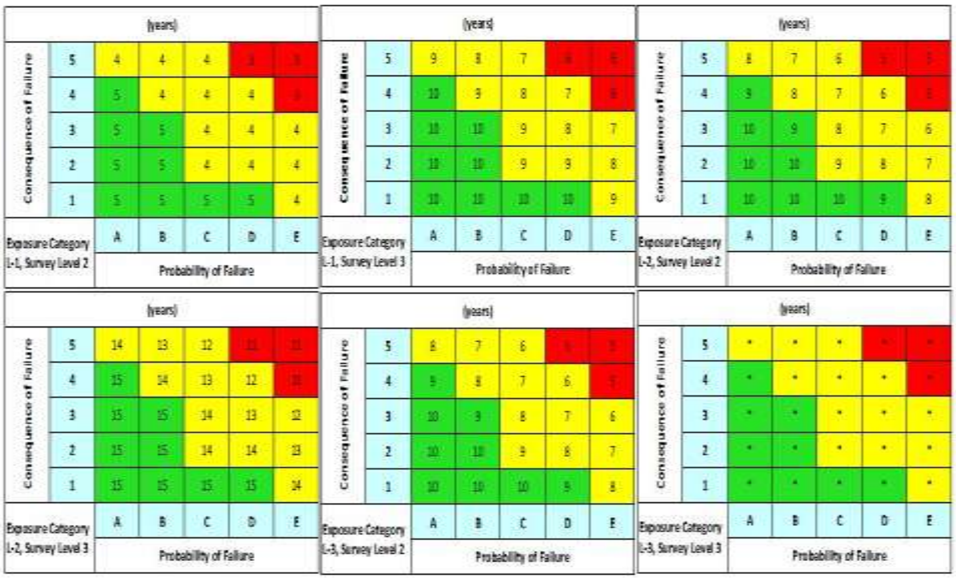
Table 6: API Recommended Survey Level Based Inspection Program

Exposure Category Level	Survey Level (years)			
	I	II	III	IV
L-1	1	3 – 5	6 – 10	Case by Case only
L-2	1	5 – 10	11 – 15	
L-3	1	5 – 10	Case by Caseonly	

Note: "Case by Case Only" means this level of inspection is only performed based on the risk or level or damage found during prior inspection level II or III

VII. INSPECTION PLAN

Risk based inspection intervals are then assigned to each platform based on the matrix of the interval. The number indicates the inspection interval (years). API RP 2A-WSD determines the inspection interval which varies depending on the exposure category (L-1, L-2 or L-3) and the survey level (Level 1, Level2, Level 3 or Level 4 whereas level 4 inspection needs to be carried out only if necessary). Therefore, aside from the survey level 1 inspection that need to be carried every year, there will be 2 inspection plan matrices (for two survey levels) for every exposure category (L-1, L-2 and L-3).



Note: (*)Only carried out if necessary

Figure 2: Inspection Interval Matrix of Exposure Category L-1 to L-3 and Survey Level 2 to 3

Detail of survey interval for each risk category is determined by expert judgment with the guidance of API RP 2A-WSD survey interval rules as shown in the tables below. Inspection interval for exposure category L-1 and survey level 2 is 3-5 years, while inspection interval for exposure category L-1 and survey level 3 is 6-10 years. Inspection interval for exposure category L-2 and survey level 2 is 5-10 years, while inspection interval for exposure category L-2 and survey level 3 is 11- 15 years, as shown below. While, inspection interval for exposure category L-3 and survey level 2 is 5-10 years, while inspection interval for exposure category L-3 and survey level 3 is only carried out if necessary which is marked in the risk matrix as asterisks (*) (or if inspection level 1 and 2 results state it to be necessary).

VIII. INSPECTION INTERVAL PLAN OVERRIDE

Fatigue failure in offshore platform is a major concern and therefore the RBUI assessment methodology will follow the flowchart in Figure 3 to specifically consider the interval plan override rule in case of fatigue remaining life is very low which usually occurs in aging platform. Sample of inspection plan is described in Table 7.

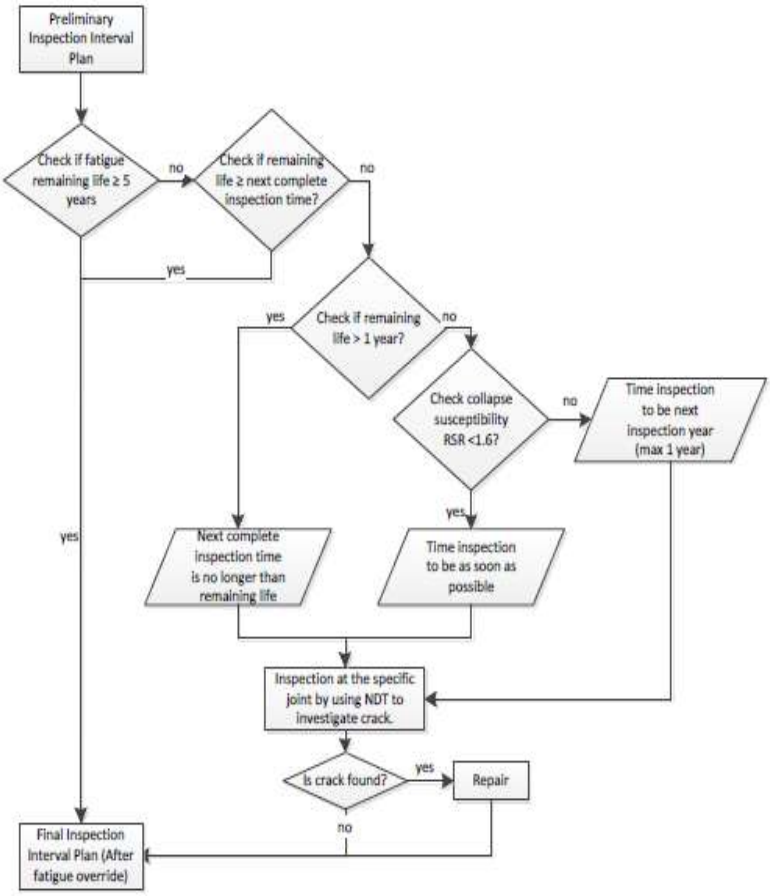


Figure 3: Fatigue Override Flowchart

IX. SPECIAL CONSIDERATION FOR AGING PLATFORM

RBUI results is specific in each Company's field. Especially for fields which have many aging platforms which over its intended design life, a special consideration can be applied. In this study, it is considered that whatever the inspection interval plan value for inspection level 3, the interval may not more than 8 (eight) years. This is a practical value which is negotiated between platforms operator, contractor and owner.

X. CONCLUSIONS

From the proposed RBUI methodology and sample analysis above, it can be seen that RBUI processes is mixed of guided development of standards and codes, mixed with qualitative experiences, determination, and judgment of experts and industrial practitioner from offshore platforms (risk and inspection) industry with discussion and open study with government as a regulator. In addition, the results of sample analysis above indicate that different characteristic of platform generates different results of risk ranking, exposure category, and a different inspection interval plan. Differentiation range comes from different characteristic and condition of each platform. The primary purpose of implementing RBUI is to highlight platform risk and prioritize the inspection. From the risk matrix, it can be seen each level of platform risk. From the inspection interval table, it can be seen when and which level of platform should be inspected. Aging platforms have major problems on fatigue life so special treatments such as overruling inspection interval plan and special consideration to give limitation on the maximum RBUI interval need to be considered.

Table 7: Sample summary of inspection interval plan (interval plan override due to fatigue is implemented)

No	Platform ID	PoF	CoF	Risk	Exposure Category	Inspection Interval (yrs)			Last Inspection (Level 1)	Last Inspection (Level 2)	Last Inspection (Level 3)	Next Inspection		
						Level 1	Level 2	Level 3				Level 1	Level 2	Level 3
1	A	D	5	High	L1	1	3	6	2014	2013	2011	2015	2016	2017
2	B	E	5	High	L1	1	(a)	(a)	2014	2013	2011	2015	2016 (a)	2016 (a)
3	C	C	1	Low	L3	1	8	*	2014	2013	2011	2015	2021	*
4	D	E	5	High	L1	1	(a)	(a)	2014	2013	2011	2015	2016 (a)	2016 (a)
5	E	E	5	High	L1	1	(a)	(a)	2014	2013	2011	2015	2016 (a)	2016 (a)
6	F	E	5	High	L1	1	(a)	(a)	2014	2013	2011	2015	2016 (a)	2016 (a)
7	G	D	1	Low	L3	1	8	*	2014	2013	2011	2015	2021	*
8	H	E	5	High	L1	1	(a)	(a)	2014	2013	2011	2015	2016 (a)	2016 (a)
9	I	C	3	Medium	L2	1	8	8	2014	2013	2011	2015	2027	2019
10	J	C	3	Medium	L2	1	8	8	2014	2013	2011	2015	2027	2019

Note: (*) Only carried out if necessary

(a) Should be conducted due to interval plan override due to fatigue

ACKNOWLEDGMENTS

The authors would like to recognize the good work of the scientists at higher education researcher, the engineers at an oil company, and the government officials at energy and mineral ministry who helped and performed, and/or are performing, the research described in this paper.

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