Offshore Oil and Gas

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The integrated Preliminary Hazard Analysis methodology regarding environment, safety and social issues. The platform risk analysis study case

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ABSTRACT: The preliminary risk analysis is one of the most popular risk analysis tools in Brazil and it's been used in so many Industries and enterprises, to support decision in terms of risk reduction. The most of cases, despite being used it's has specific focus regarding environment or safety issues. In operational situation, it's been done before a specific operational activity and it's not a problem but in case of project it's necessary to have an integrated approach regarding environment, safety, health, organization image and local society.

The mean objective of this study is propose an integrated Preliminary risk analysis approach to support decision in risk reduction and it'll be used a Platform study case as instance of that methodology application.

The study steps will be definition of risk qualification with it's probability and consequence range, systems and subsystems definitions, hazards and environment aspect involved, recommendations to risk reduction, and critical analysis about this methodology regarding positive and negative point.

1 INTRODUCTION

The PHA analysis come from military industry application as a reveal technique applied to check missile system launch. In that case, 4 of 72 missiles intercontinental atlas was destroyed with high cost.

Nowadays, the PHA is applied in many industries in operational activities or project conceptions. So, no matter this application, that mean objective is support decision in order to avoid accident and eliminate unsafe conditions.

In most of cases in Brazil, that kind of analysis has a specific focus in environment or safety. It's good in terms of faster problems solutions in operational areas but in case of project that individual approach increase analysis cost and in some cases the same action which solve unsafe and environment impact condition are not suggest.

In order to safe money, time and integrate problems resolution an integrated PHA was implemented in Brazilian oil industry. Beyond safety and environment, it's takes company image in case of catastrophic accidents.

That paper has the mean objective to propose the integrated preliminary risk analyze, with drawback and advantages based in an onshore study case.

2 THE PRELIMINAR RISK ANALYSIS IN BRAZIL

The preliminary hazard analysis or preliminary risk analysis is qualitative technique which has the mean objective to identify a hazard condition and propose some action to eliminate that. So its necessary identify hazard involved, the causes an actions to control or eliminate the unsafe condition.

The hazard concept is any kind of situation, product or process with cause accident and accident is a process deviation which cause damage to employees health. In some cases, it's necessary to analyze the hazard frequency and accident consequence, so the risk is defined as a hazard frequency and effect consequence combination. That approach is usual in project application because is necessary to propose recommendation to control or eliminate the risk. In operational activities, the mean objective is control the risk to perform activities, so risk qualification is not used in so many cases.

There are so many risk qualification matrix as shown in table 1 below and it's takes a argue about which one is more effective in risk qualification. As a matter of fact, the simplest matrix makes many situations similar and the harder matrix makes analysis more difficult to be performed. By the other way round, the risk policy its very important in order to control or eliminate the risk, because in so many cases, the modifications are propose only in catastrophic effect or critical risk, that result from high possibility of danger and high effect.

In that table above there are five levels of accident frequency from 1 year until 100000 years. In fact, that's difficult to classify because that frequency not happen in the real case. So the first observation is to define a feasible period of time and it's

Table 1. Risk matrix.

							FREQUENCY CATEGORY				
			Description and caracteristic				A (extremely remote)	B (remote)	C (Lettle frequence)	D (Frequent)	E (Very frequent)
			PERSONAL SAFETY	INSTALATION	ENVIRONMENT	IMAGE	At least 1 once in 100.000 years	At least 1 once betwen 1000 and 100.000 years	At least 1 once betwen 30 and 1000 years	At least 1 once betwen 1 and 30 years	At least 1 once in 1 year
SEVERITY CATEGORY	IV	Catastofic	Cathastrofic injures with death, its possible to effect people outside	Losses in equipment and plant with high cost to buy the new one	Loss of ecosystem with	bad national and international company image reputation	NT	NT	NT	NT	NT
	III	Critical	Critical injuries. Employees stay a period oftime out of workplace	Equipment serius damaged with high cost to repair	Critical effects to enviroment being hard to improve eosystem condition even with human actions.	Bad national and international company image reputation	M	M	M	NT	NT
	II	Marginal	Moderate injuries with firt aid assistence	Low equipment damaged with low repair cost	Not serius enviroment effect but its necessary human intervention and actions to improve environment.	Bad national company image reputation	T	T	M	M	M
	I	NOT EFFECT	Theres no injuries and health damaged	There is not damaged to equipment and plant	Insignificant environment effect. There is not necessity to human action to ecosystem improvment.	There is not nacional company image reputation bad effect	T	T	T	M	M

necessary to have not a huge range between frequency classifications.

Regarding the consequence classification, it's must to clear the difference among each level. In that particular matrix, there's confusion between employees damages and external population damage, maybe it's necessary to make up one column to classify external social losses.

The combination between frequency and consequence result in risk that is tolerable, critical and intolerable. In most of cases in Brazil, when risk is intolerable one specific action have to be done to reduce at least to critical level. In fact, the critical risk cause serious environment impact and health disturb to employees and society. So the risk policy which defines actions to control or eliminate risk must be conservative in order to prevent accidents.

The other important limitation in that matrix risk approach is to consider unsafe condition with a constant probability. In fact, the layer protection and accident happen based in PDF (density function probability) and in not all cases the probability is constant. Therefore, if that approach is considered the risk level will change along the time. That statement is reasonable due the fact that equipment and layer protection getting older along time and there are different equipment with different characteristics.

Despite the risk matrix limitations, it's not usual in Brazil to perform an integrated risk analysis in order to prevent environment impact and health damages. Even in project analysis, is usual to perform to PHA with different focus as environment and health and safety.

The Brazilian Government requires PHA to approve environment project license. There are tree different kinds of environment license. Preliminary, Installation and Operational. In fact, the Environment impact analysis is required in most of case and to get installation and operational license is necessary to perform risk analyze. In Oil and Gas Brazilian industry, due

to critical hazard condition, it's necessary to perform PHA and AQR(quantitative risk analysis) to check vulnerabilities. In that specific case, there's an integrated analysis in order to check vulnerability.

3 THE ENVIRONMENT VALUATION

The Environment valuation was accept for EUA congress as the best methodology to be applied in Exxon Valdez Accident in EUA as way to define the economic value to environment accident aspect as economical value in local activities losses and economical value in environment resources losses. That methodology despite not usual in Brasil, must be applied in order to provide an economic environment quantification to perform prevention and layers of protection and to valuate environment resources.

The basic concept of that methodology is that whenever is there a losses in social welfare, it's must be compensate and the social welfare has an economic value. Therefore, there's a good production level associated with pollution quantity which the social welfare is not disturbed, because social cost compensate the social welfare. Beyond some production level, over than one specific pollution level, there's welfare lost and it's must be compensate. To avoid that situation, economic instruments as index in environment resources or product, level of production specification, restrict laws are performed by different ways.

So it's important to define the environment valuation regarding different aspect as direct and indirect social cost. The environment valuations regards use value and not use value. The value use comprises direct use value, indirect use value and future option use value. Not used value comprise only existence value.

The direct use value is associate environment resources with production or any economic activity which consume raw material or natural resources as fishing or agriculture for instance.

The indirect value is associate with some environment resource that you use indirectly like the air or water.

The future option value use is associated with some resource that not being used in the present but it may be used in the next future like some species in Amazon forest which can be used in some medicine.

The not used value comprise existence value and it's associated with some moral issue and wish to preserve some specific species like white tigers for instance.

To calculate each specific value is necessary some methodologies as Function Production method and Function Demand method. The first one, Function Production Method, regards that one specific product has a direct relationship with natural resource and if that resource is not available the product price chance, so it's possible to estimate the natural resource economic value based in product price variation when that natural resource is not available or that's quality is not good due to some pollution effect.

The second method, Function Demand method regards the relationship between one natural resource and one product or service in terms of characteristics, so the product or service economical value depends on natural resources quality. In case of a house or flat for instance, the economics value depends on how much pollution is around that build or if there's is a good beach near that build, people is disposal to pay more to live in that build.

To estimate existence value is necessary on specific demand method Known as The contigent value method, which requires to estimate how much people are disposal to pay to preserve some specific natural resource. To preserve one specific forest, species and so on. That's related with existence value.

So it's possible to estimate the natural resources value and social cost in case of environment accident and pollution. Based in one famous accident in Brazil it's possible to associate the economical value with the accident risk level. In 2000, the Baia de Guanabara accident had so many effects which were classified as suppliers and consumers effects.

The suppliers effect comprises economics activities as fishing, Tourism and ship transportation. So the first step was measure the accident effect in each activity and after estimate the productions losses associate with product or service demand in accident period with other period of time.

The consumer's effect comprises losses in quality of life and health. The first one is associate with how much people are disposal to pay to have natural services as beach free of environment accident effect and the second one is associate with health disturbed caused for environment accident effect. The table 2 below shows the economical environment value to each consumers and suppliers effect.

Table 2. Economics Value Resource – Monteiro, 2003.

Economy Sector	Economics Value
Suppliers losses	
Transportation	R$ 269.100,00
Tourism	R$ 1.506.180,00
Fishing	R$ 2.021.997,00
Natural resources	R$ 96.514.427
Consumers losses	
Health	R$ 565.885,00
Quality of life	R$ 234.666.965,00
Total	**R$ 335.544.555,00**

The mean objective to present that methodology is state one specific social value associated with different risk levels. There are four risk levels as.

- Minimum
- Marginal
- Critical
- Catastrophic

The new matrix below in tables 3, 4 and 5 associate the social value with each risk level. So the new risk matrix comprises safety, environment and social effects as shown in table below. It's very important to show that is must be considered only for onshore activities. In offshore activities is necessary to regards different environment resources and social effect which requires other Environment valuation study.

The severity category comprise the categories as the new social column describing each social value associated with risk severity.

The matrix below show the frequency that must be related with severity resulting in risk level describing by one specific level which vary from 1 to 4.

The final risk matrix comprises severity and frequency resulting in risk value. The risk must be non tolerable (NT), moderate (M) or tolerable (T) as shown below.

Risk levels.

		FREQUENCY CATEGORY				
		A	B	C	D	E
SEVERITY CATEGORY	IV	NT	NT	NT	NT	NT
	III	M	M	M	NT	NT
	II	T	T	M	M	M
	I	T	T	T	M	M

In non tolerable risk level, some action as project or technology modification is required in order to reduce the non tolerable risk to moderate risk. If there's no how to reduce risk level, reducing the severity or frequency the project must be given up. In moderate risk level is required risk management in order to avoid the risk level increase from moderate to non tolerable. In tolerable level, management risk is required but is not so serious like the other risk levels. The consequences is acceptable despite is required to try to avoid accidents. That new risk matrix is a new approach regarding environment valuation and it's a propose to next PHA that will be performed in onshore industry. In study case presented in this paper was used the matrix shown in table 1 and due some difficulties when performed that risk matrix, not including social value losses, was necessary to make some improvement in risk matrix.

4 THE PHA METHODOLOGY

Despite to be a simple risk analyze, in project case it's more complicate to perform that, so it's necessary to follow some steps in order to avoid to forget to take into account any important hazard situation.

First is necessary to define systems and subsystems, second in each subsystem must be defined which equipment is being analyzed, third the hazard, it's causes and consequence and risk qualification have to be defined and finally in the last step, the recommendation to control or eliminate the risk.

More important or so important as risk qualification is risk management along project. The great advantage to perform PHA in project is to identify the hazard and propose some action to mitigate the risk. The difficulties are several as different teams working together and in different parts and project times which requires a very good information management, coordination and project management. Even after project, its means, when operational phases stars its necessary to keep improvement, monitoring risk to keep hazard under control. In operational phase ill be test out all recommendation and actions proposed in project to avoid accident and environment impact. The risk management steps is shown in figure 1 below.

The remarkable part of risk management is the necessity to update periodically the information about hazard situation and whenever it's necessary to propose some action to risk mitigation.

5 THE PLATFORM STUDY CASE

That platform study case has the mean objective to show how the integrated PHA is possible to be performed to big projects and to discuss about the advantages and drawback about that approach.

Table 3. Severity category.

			Description and characteristic			
			PERSONAL SAFETY	INSTALATION	ENVIRONMENT AND IMAGE	SOCIAL
SEVERITY CATEGORY	IV	Catastofic	Cathastrofic injures with death, its possible to effect people outside	Losses in equipment and plant with high cost to buy the new one	Loss of ecosystem with bad national and international company image reputation	Economics effects in local activities, health cost in local population, economics losses in turism, ecosystem local losses and quality of life losses. (Betwen R$ 101.000.000,00 and R$ 336.000.000,00)
	III	Critical	Critical injuries. Employees stay a period oftime out of workplace	Equipment serius damaged with high cost to repair	Critical effects to environment being hard to improve ecosystem condition even with human actions. Bad national and international company image reputation	Economics effects in local activities, health cost in local population, economics losses in turism, ecosystem local losses (Betwen R$ 2.500.000,00 and R$ 101.000.000,00)
	II	Marginal	Moderate injuries with first aid assistence	Low equipment damaged with low repair cost	Not serius enviroment effect but its necessary human intervention and actions to improve environment. Bad national company image reputation	Economics effects in local activities, health cost in local population, economics losses in turism, fishing and the others (Form R$ 0,00 to R$ 2.500.000,00)
	I	NOT EFFECT	Theres no injuries and health damaged	There is not damaged to equipment and plant	Insignificant enviroment effect. There is not necessity to human action to ecosystem improvment. There is not national company image reputation bad effect	There is not economics effects in local activities, health cost in local population

Table 4. Frequency category.

FREQUENCY CATEGORY				
A (extremely remote = 1 once between 20 and 50 years)	**B (remote = 1 once between 10 and 20 years)**	**C (Lettle frequency = once in each 10 years)**	**D (Frequent = 1 once in 5 years)**	**E (Very frequent = More than once per year)**
At least 1 once between 20 and 50 years	At least 1 once between 10 and 20 years	At least 1 once between 5 and 10 years	At least 1 once in 5 years	At least 1 once in 1 year

Table 5. Accident in oil industry resourse : Moraes, 2001.

March 1980	North Ocean	Platform *Keillan*	123 deaths
October 1981	China ocean	The ship	81 deaths
September 1982	North atlantic	*Ocean Ranger*	84 mortos
August 1984	Campos Brasil	Platform explosion *PETROBRAS*	37 deaths
May 1988	Campos Brasil	Fire in em platform *Enchova - PETROBRAS*	
June 1988	North Ocean	*Piper Alpha*, Platform explosion	167 deaths
December 1991	S. Paulo Brasil	Explosion in brasilian ship	1 deaths
2001	RJ Brasil	P-36	11 deaths

The production platform is a system which works with specials conditions in terms of operability, safety, environment and so on. That reason justify the PHA in project in order to perform some preventive action. In last century there was so many accidents in different countries in Oil and gas industry as show in table 5.

The number of accident shows how important is the risk analysis in project to avoid catastrophic accidents.

In that plataform study case was took into account 19 systems as:

- Oil Feed;
- Oil treatment;
- Oil exportation;
- Gas;
- Amine regeneration;
- Glicol regeneration;
- Gas booster;
- Gas feed;
- Water injection;
- Water produced;
- Heat water;

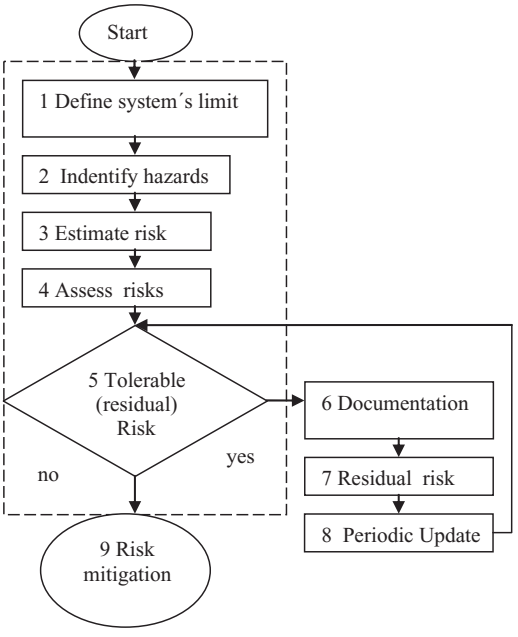

Figure 1. Risk assess resouse : Moergeli, 2001.

- Flair;
- Atmospheric vent;
- Diesel;
- Closed drain;
- Open drain;
- Open HC classified drain;
- Open classified area drain;
- Open non classified drain.

Each system were divided in subsystem and each subsystem was define the node to be analyzed regarding all possible hazard involved that's in so many cases cause hard argue about what must be taking into consideration. In Brazil, is not usual to take into account catastrophic natural event as twister, earthquake and so on. The other difficulty I to limit the detail or hazard involved, so based in draw available is took into account only the possible situations that's happens with equipments that are in draw. Ergonomics issues for instance is not took into account due no to be possible to get into conclusion about specific details in workplace.

After define the system sub-system and it's parts the hazard are identified, the possible causes are discussed and consequence and detection are assessed. Therefore if it's possible the recommendation is propose in order to mitigate the risk. The hazard identification is shown in table 6.

The hazard identification were performed for the whole platform, after that, it's necessary to qualify the risk. It's means to define the hazard frequency and

Table 6. PHA matrix (hazard identification).

Hazard	Causes	Consequence	Detection/ safeguard
Oil and gas flow	Corrotion in pipe line.	Gas formation with Explosion and fire	Visual
	Troughtout in conetion valve	Ocean contamination by oil	Visual

Table 7. PHA matrix (hazard identification).

Freq.	P		Int.		Env		Image	
	S	R	S	R	S	R	S	R
E	I	M	I	M	I	M	I	M
C	I	T	I	T	I I	M	I	T

Table 8. Risk qualification.

	People	Installation	Environment	Image
Tolerable	26	57	83	97
Moderate	103	77	51	36
Intolerablel	5	0	0	1

it's consequence in terms of people, installation, environment and image. The table 7 below show the risk qualification related to table 2 hazard.

Regarding the hazard, little oil outflow, there will be gas formation or ocean oil contamination. In the first case, despite frequent to have little oil outflow the consequence to people, installation environment and image are moderate, it's means that's even that happen, local resource is enough to control the situation.

In second case, it's feasible to happen ocean oil contamination, despite the consequence is worse than the first one to environment.

So that's methodology permit to discuss about platform hazard, it's effect, consequence to people, environment, installation and company image. The whole systems and sub-system was assessed taking two weeks, being involved o group of engineers, technical in safety, platform operators, risk specialist and project coordinator. The PHA result was 47 recommendations to mitigate risk in this platform. The table 8 summarizes the PHA analysis in terms of risk and show that platform is more danger to people due five of six intolerable risk is related with people health.

6 CONCLUSIONS

The integrated PHA performed in platform study case allow to take into conclusion the importance in analyze the hazard involved in project in advance to permit propose so many actions in order to improve safety and mitigate risk.

The drawbacks are the difficult to analyze an qualify hazard regarding people, installation, environment and image in same time, so it's necessary to trainee people in this approach. Second, it's necessary to define frequency very well and consider accident historical event and if it's possible define PDF (probability density function) for accident and layer protection meanly to the most critical events. The huge challenge is to keep looking the recommendation along project life and reanalyze whenever is necessary the hazard involved.

The advantages are the integrated problem vision which permit project team to have integrated solutions to project problems. Second the possibility to improve project in terms of risk mitigation and safe money and time when it's performed only one integrated analyze despite two analysis with different focus in environment and safe issues.

It's necessary to improve qualitative matrix and include a society column to consider external damages and health disturb, discuss the risk change along time and test that approach for different kind of project to analyze the results.

It's necessary to consider social effect based in environment valuation analysis, despite it's a difficult methodology to be performed is a new quantitative approach which takes a good social value loss perception.

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