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Risk Assessment and Emergency Response of Oil Spill for Offshore Oil Activity

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Abstract

With the greatly development in offshore gas and oil activity in China, the potential risk of oil spill attract more public attentions. In order to effectively limit the spilling incidence and and bring it under control, it is necessary to establish a risk assessment model for offshore petroleum activity and prepare the oil spill response resource in an effective way. In this paper, a quantified risk assessment model, including the spill probability and consequence assessment, was developed using fuzzy comprehensive method. The spill probability assessment was established with view of the operative manual and statistic leakage/damage data of different kinds of offshore petroleum facilities and operation; the consequence assessment was proposed to several factors including the spilling volume, property of spilled oil, spilling location and the elements of spilling detection and controlling capability of operator. Based on the result from risk assessment, we can identify the comprehensive spill risk level (low, ALARP, high) and make a decision whether the response resource allocated to the site could be enough. The multiply oil spill response devices and facilities, especially the oil recovery vessel, were largely used in China and will be expand in future.

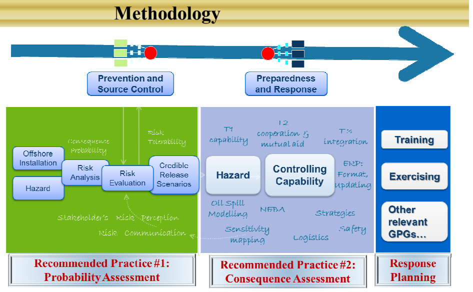
Background & Objective

China Offshore Environmental Services Co. Ltd (COES in short) is always sticking to the National Strategy to combat pollution of the sea by spill oil since its establishment. It is well known that frequent oil spill incidents caused by ship , tanker, pipeline, as well as platform in previous ten years in China, which resulted in approximately thousands of tons of oil leaking and polluting the sea. Since after serious incidents, the greater public demand for environmental responsibility and stricter environmental enforcement led to an issue about how to prevent and control the sudden oil-spill for the specific petroleum facilities.

Currently, COES has a full scope of services in oil spill response and has its R&D Department which is always focusing on the advanced technology and breakthrough in prevention, oil spill control, trajectory forecasting as well as oil recovery. Now COES has succeed organizing the response operation, drilling and training for several times in China as well as in foreign.

Methodology

Fig 1. Framework of risk assessment of oil spill for offshore oil production activity which shall combine the probability assessment and consequence assessment.



Step 1. Probability Assessment

Table 1. Oil spill probability analysis for oil-production activity

No	Risk Source	Incident Risk Description / Incident Explaination	Frequency
1	Fire and explosion	When it happens for the rupture of pipeline and container, failure of wellhead control as well as gas or oil leaking, once in the case of fire, there will be explosion and huge fire incident. The failure operation is the main incident risk.	Unit：per year • Oil & Gas Transmission：3×10^{-4} • Oil & Gas Treatment：4×10^{-3} • Oil Storage Area：2×10^{-3}
2	Leaking from pipeline	Exterior potential risk for leaking of pipeline shall be concluded as the impact of falling weight, trawling, dredging, pipe-laying, anchor dropping, shipwrecks, natural hazard. Interior potential risk shall include: corrosion, failure of structure and material as well as failure operation.	Unit：per km•year • 300 m from platform: 8.4×10^{-3} • 1 km from platform: 6.4×10^{-3} • With 80 cm coating: 2.7×10^{-2} • With 100 cm coating: 7.9×10^{-4}
3	Leaking of riser	The main reason shall include: collision, natural hazard, corrosion as well as material failure.	Unit：per year • Diameter of riser pipe > 30"：1.3×10^{-3} • Diameter of riser pipe < 28"：5.6×10^{-3}
4	Leaking of fuel oil or oil hose leaking in offloading	Rupture of oil container of platform and vessel, operational failure in oil offloading	• Lower than 10^{-5} per year
5	Leaking of FPSO	Risk source can be concluded as oil offloading and the FPSO accident causing by the bad weather	• By oil offloading : oil leaking volume more than 1000 barrel: 0.037 per 1 billion barrel
6	Geology risk	Stratigraphic structure is fragile and the injection pressure is higher than stratigraphic pressure.	• Lower than 10^{-5} per year

Fig 2 . Total worldwide oil spillage by percentage for various source categories, 1990-1999.

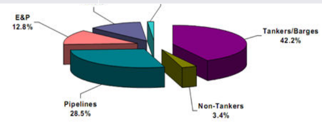
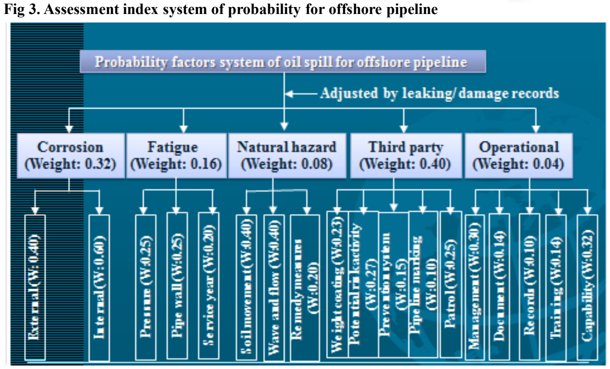
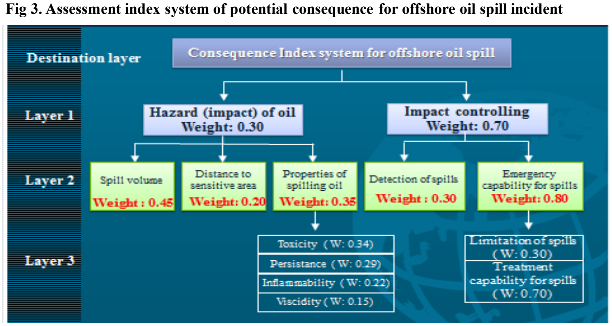


Fig 3. Assessment index system of probability for offshore pipeline



Step 2 Consequence Assessment

Fig 3. Assessment index system of potential consequence for offshore oil spill incident



Step 3 Total Risk Scours

Following the modified procedure, the total risk were ranked as follow:

Total Risk Score= Probability×Consequence

Table 2. Risk matrix of integrated risk assessment for offshore petroleum activity

Risk=Probability ×Consequence		Spill Consequence 10-29	30-49	50-69	70-89	90-100
Oil Spill Probability	90-100	M	H	H	VH	VH
	70-89	M	M	H	H	VH
	50-69	L	M	M	H	H
	30-49	VL	L	M	M	M
	10-29	VL	VL	L	M	M

Example Case

In this poster, we take example with an exited offshore pipeline in Bohai waters and discuss the reliability of the developed frame structure of probability and consequence assessment for offshore oil spill:

Table 3. Probability (upper) and consequence level (lower) of oil spill incident

Evaluated factors	Initial evaluation	Overall evaluation	Probability score
Corrosion	(0.02, 0.19, 0.53, 0.22, 0)	(0.08,0.25,0.43,0.17,0.03)	V_{pro}=54.09
Fatigue	(0, 0.20, 0.60, 0.20, 0)		
Natural hazard	(0.04, 0.28, 0.52, 0.16, 0)		
Third party	(0.17, 0.34, 0.32, 0.12, 0.05)		
Operational	(0.17, 0.60, 0.23, 0, 0)		
Evaluated factors	**Initial evaluation**	**Overall evaluation**	**Consequence score**
Hazard of oil	(0.02, 0.50, 0.39, 0.09, 0)	(0.24,0.35,0.17,0.07,0.17)	V_{con}=42.98
Impact controlling	(0.34, 0.29, 0.07, 0.06, 0.24)		

- If the value of probability level caused by each evaluated factor is more than M (moderate, Vpro=50), it suggest the oil spill incident has a high probability in the following years, and more attentions should be paid to the corresponding factor by trying to avoid worsening conditions.
- In this case, corrosion was determined as the critical spill-probability factor, thus the corrosion inspection should be proceed periodically.
- Totally, The integrated oil-spill risk was also ranked as M according to the risk matrix listed in this. So ALARP principle should be adopted and determine whether the remedy or control measures should be conducted based on the demands of inspection report.

Acknowledgement

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