

# Analysis of Oil Spill Factors on Offshore Platforms and Suggestions for Prevention and Control

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**Abstract:** Under the background that offshore oil and gas exploration projects are increasingly being valued by all countries, it is more and more important to reduce the probability of oil spill accidents on oil production platforms. To this end, the author analyzed the causes of platform oil spill from four aspects: platform characteristics, well control failure, natural environment, storage and transportation structure damage, and obtained the main influencing factors of platform oil spill. And on this basis, the author put forward some immature suggestions for the platform from design, construction and installation to operation. Finally, hoping that in the future, on the basis of the combination of informational technology and oil spill prevention and control, the losses caused by oil spill can be greatly minimized.

**Keywords:** Oil Spill Factor; Risk Prevention And Control; Oil Spill Risk Management

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## 1. Overview of offshore platform oil spill research

Under the background of mature land mining resources exploitation technology and declining reserves, the research and progress of offshore oil and gas exploration projects have been paid more and more attention by governments of various countries. However, in the process of offshore oil and gas exploitation, there are still many problems need to be solved urgently. In April 2010, a serious crude oil spill accident occurred in the Gulf of Mexico in the United States, causing immeasurable losses in terms of economy and global ecological environment. According to the consequences of the oil spill, the impact can be roughly divided into three aspects. First, the oil spill will cause serious harm to the marine environment. The oil will form oil film on the water surface, hindering the exchange of carbon dioxide, oxygen and organic substances in the sea with the atmosphere. The occurrence of oil film also affects the respiration of marine organisms<sup>[1]</sup>. Compared with the impact of oil spill on land, the oil spill at sea has the characteristics of faster diffusion, wider pollution range and longer impact time<sup>[2]</sup>. Secondly, the oil spill will also cause damage to marine biological resources. In the marine ecosystem, plankton accounts for most of the total organisms, and the oil spill has the greatest impact on them. Affected by the oil film, the oxygen exchange rate between plankton and the outside world is greatly reduced, and then suffocate to death. For juvenile fish, the oil film will have an adhesion effect on the eggs, and reduce the activity of juvenile fish until it is poisoned to death. Finally, the oil spill will also have an impact on human productions and lives. When the oil spill area is close to coastal factories, contaminated water may interfere with the operation of equipment. From the perspective of human diet, when people eating contaminated seafood, the carcinogenic substances in oil will enter the next nutritional level, which will affect human health. Therefore, the risk prevention and control of oil spill on offshore platforms is one of the important directions. At this stage, the research methods of oil spill risk analysis on offshore platforms mainly include the following: the fuzzy comprehensive evaluation method that to determine the factor sets, evaluation sets, factor index membership degree and weight of oil spill risk, the Bayesian prediction model, which based on the probability theory, and the analytic hierarchy process ( AHP ) that divides the main elements related to decision-making according to various criteria and

conducts qualitative and quantitative analysis, etc. Through these methods, a relatively complete prevention and control system for oil spill can be established.

## **2. Nalysis of the platform oil spill factors**

### **2.1 Latform features**

At the beginning of the platform design, failure to reasonably set the initial parameters in accordance with national regulations is an important factor for the tilt or even oil spill in the later stage of the paltform's launch. In the design stage, the buoyancy, stability, seakeeping and other important mechanical properties of the overall structure of the platform, the strength calculation and analysis of the structure such as wave slap analysis and vortex-induced vibration analysis are also the key to ensure the safety of the structure. When the corresponding modeling and force analysis are not completed in the early period, the oil spill of the platform will be one of the possible problems. In addition, after the platform is put into production, whether the operation capability and technology are safe and reliable are uncertain factors, and whether its emergency response capability is effective will also be one of the risk sources of oil spill.

### **2.2 Well Control Failure**

In the stage of construction, installation and operation of the platform, the failure of well control measures is an oil spill factor that cannot be ignored. During drilling and workover, the main reason for oil spill is that the composition proportion of drilling fluid or workover fluid is imbalance. Secondly, oil spill is affected by the formation pressure. When the formation pressure is too large, the well kick will occur first, and the kick off will be further induced under the condition of insufficient prevention and control measures in the later gradation<sup>[3]</sup>. In addition, if the mechanical devices such as drill pipes and blowout preventers are not applied in time or lose efficacy, or the hydrogen sulfide gas in the oil and gas composition is electrochemically corroded and hydrogen brittlely damaged with metal, it may also lead to well blowout. In the production stage, with the increase of water depth, the pressure borne by the wellhead will also increase. Also, There are many pipelines and valves near the wellhead, and the force that the wellhead need to inherit is complex. If the safety valve fails, it will constitute a great threat to the stability of the oil production system.

### **2.3 Natural environmental impacts**

The platform is always affected by the external natural environment conditions from the construction and installation to the operation and production. From the perspective of sea conditions, the existence of sea ice during glacial periods will cause impact, compression and friction effects on the platform. When the sea ice freezes with structures, additional gravity and buoyancy will be generated. When extreme weather such as typhoons, tsunamis and storms occurs, the floating platform will risk ranging from anchoring position changed, production suspended, to the structural integrity of the platform destroyed and oil production operations stopped. Besides, the influence of seabed geological conditions cannot be ignored. When an earthquake happens, the oil pipeline may be damaged, resulting in oil spill accidents.

### **2.4 Storage and transportation structure damage**

During the production process of the platform, the reasons for oil spill caused by the damage of the storage and transportation structure can be divided into two categories. On the one hand, the leakage of subsea pipelines or vertical tube. When the tug laying the pipe, it's easy to scrape the coating outside the pipe, then the pipe is more susceptible to corrosion when working on the seabed.<sup>[4]</sup> When the ship is not properly berthed, the anchor cable may wreck the pipelines' concrete weighted layer which will cause corrosion failure. In addition, although the probability of offshore platform vertical pipe

leakage is not high, affected by extreme sea conditions, geological disasters, the pipe may also be broken. On the other hand, the leakage caused by the oil pipeline. The oil pipeline is mainly used for oil transmission between oil extracting platform and the FPSO, FPSO and the oil tanker. When the oil pipeline is approaching its service life, valve failure and flange cracks may occur due to aging wear and tear. If it is not repaired or replaced in time, oil spill may occur. When the transmission process encounters severe sea conditions, ship collision may also occur and resulting in oil spill.

### **3. Prevention and control measure**

#### **3.1 Preventive control measures in the design stage**

In the design phase of the platform, the setting of various parameters and indicators should strictly comply with relevant domestic or international industry standards and regulations. <sup>[5]</sup> When setting the critical parameters of safety valves, flanges and other facilities, the qualified parameters that meet the allowable stress should be selected after the full compression test under ultimate load. When designing the service life of components of the platform, it should be set in accordance with the recurrence interval of various environmental loads, such as wave, typhoon load, etc.

#### **3.2 Prevention and control measures in the construction and installation stage**

Before drilling, a detailed plan for obtaining information such as drilling location, sea area depth and geological conditions should be formulated to ensure the progress of drilling projects working smoothly. When preparing for drilling, sufficient drilling fluid should be prepared, safe and accurate drilling tools and instruments should be equipped. In the meantime, in order to prevent accidents such as well gushing and blowout, hydraulic blowout preventer, drilling tools, back pressure, bypass valve, well control manifold and other well control equipment should also be fully equipped. Moreover, it is necessary to strengthen the training and assessment of platform operators, help staff to establish a sense of responsibility of safety, caution and vigilance and illegal operations. Meanwhile, a standard and concise emergency response plan should be formulated.<sup>[6]</sup> After the oil spill accident, using the oil spill dispersant, oil fence and other equipment to minimize oil spill pollution timely. Finally, work tasks should be reduced or suspended in severe weather, and warning signs and lights should be arranged at the borders of the surrounding safe maritime area to alert the passing ships to avoid the operation area.

#### **3.3 Prevention And Control Measures In The Production And Operation Stage**

In the production stage, the monitoring of various indicators of the platform, such as hydrocarbon gas, formation pressure and temperature, should be strengthened in combination with scientific, technological and intelligent means. When the indicators are at abnormal values, the causes should be investigated and whether they can have influence on the oil production operation should be determined immediately, if there's an impact, the operation should be suspended and the problems should be solved in time.<sup>[7]</sup> Regularly check whether the platform equipment is operating normally to avoid accumulating hidden dangers, if there's a problem, it should be repaired or replaced at once. The safety of the platform operation area should be inspected from time to time. Dispatch the ROV to check the submarine pipelines and vertical pipes, and clean up the marine organisms attached to the subsea pipelines in time to avoid affecting the coating or other material corrosion of the pipe walls. Improve the psychological quality of the platform staff and conduct regular safety drills to make sure they can calmly deal with emergencies at risk. Attach main operation steps instructions to complex facilities and

equipment to prevent staff forgetting. When the platform carries out oil transportation with FPSO, if they encounters extreme weather, FPSO should sail out of the operating waters in time to prevent collision.

## 4. Summary

The consequences of oil spill on offshore platforms are serious. When the oil spill accident occurs, it will have a more or less impact on the ecological environment around the sea area. Therefore, on the basis of careful analysis of oil spill causes, it is significant to establish a hierarchical evaluation system and oil spill factors database. The oil spill risk management system formed by the combination of the two can qualitatively and quantitatively assess the possibility of oil spill risks of offshore platforms, and then on this basis, focus on prevention and control. Hoping that in the future of the combination of informatization and risk prevention and control, mankind can minimize various losses caused by oil spills.

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