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# A Study on the Migration and Diffusion Hypothesis of Oil Spills Across the Pipeline

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## Abstract

**In order to clarify the logical relationship between oil spill behavior and emergency response, the five-stage hypothesis of oil spill migration and diffusion across pipelines was expounded in view of the migration and spread law of oil spills across pipeline projects in torrent rivers, and the principles and main features of each stage were analyzed. characteristics, and summarizes the diffusion law of crude oil in rivers, so as to provide a theoretical basis for the safety and emergency repair of oil spills in pipeline crossing projects.**

## Keywords

**Pipeline spanning project; migration and diffusion; pipeline leakage; emergency repair.**

## 1. Introduction

The mountain pipeline crossing project has the characteristics of high pressure, high strength, high frequency of geological disasters, large diameter, and large transportation volume. In addition, the oil and gas medium itself is flammable, explosive, and toxic. The inflow into the water will not only pollute the water quality of the river, but also cause serious consequences such as loss of life and property safety, environmental damage and production impact [1]. At present, there are many studies on oil spill accidents in fixed blocks at home and abroad, such as oceans, reservoirs, bays, lakes, etc., while there are few studies on river oil spills, especially on torrent rivers, which can be found at home and abroad. There are few references and methods [2]. This paper describes the five-stage hypothesis of oil spill migration and diffusion across pipelines, and analyzes the main characteristics of each stage.

## 2. Five-stage hypothesis of oil spill migration and diffusion across pipelines

The leakage of pipelines across rivers, from the moment when the medium leaves the pipeline to the moment when the medium is intercepted and recovered, belongs to the migration and diffusion process of oil leakage. Here, from the microscopic and macroscopic perspectives, using time as a clue, five stages of oil leakage migration and diffusion are proposed. Hypothesis, namely free fall motion, oil spill floating, turbulent cross-section expansion, longitudinal drift, and cross-section expansion under the action of the oil boom [3].

The first stage, free fall motion under the action of gravity.

Since the position of the crossing pipeline is higher than the river surface, if the influence of the bridge surface is ignored when the oil leaks, the liquid droplet or liquid flow will first move freely under the action of gravity until it touches the river surface [4]. At this stage, the oil leakage speed and movement time mainly depend on the height of the bridge, and the wind direction and wind speed will change its movement trajectory and droplets to a certain extent.

In the second stage, the oil spill floats up.

After the oil spill contacts the river surface, it simultaneously receives the effects of its own gravity and the buoyancy of the river water. Since the density of crude oil is smaller than that of water, under the action of the initial velocity, the crude oil first decelerates and sinks in the water, and then slowly rises to the surface [5] ]. If the water flow velocity is high, in this process, due to the action of the water flow, there will be accelerations in both vertical and downward directions; At this time, the oil droplets may directly contact the oil spill, and the vertical velocity will be reduced to zero before entering the water, and the oil floating process will be shorter at this stage.

In the third stage, the turbulent cross section expands.

It is assumed that all oil droplets/flows surface from the same section under the action of gravity, buoyancy and water scouring. Since oil and water are difficult to accommodate, in this section, if the eddy current effect is ignored, it can be considered that the vertical velocity is zero, and the overflow occurs. After the oil reaches the water surface at this section, the oil spreads laterally and longitudinally on the water surface into an oil slick. At this stage, initially under the action of oil-water interface surface tension, inertial force and oil-water viscous force, even in the absence of wind and water flow, oil spills will form an oil film with a thick middle and a thin edge on the water surface; over time With the passage of time, under the resistance of viscosity, the diffusion rate of the oil film is significantly reduced, and the oil film spreads horizontally to both banks and downstream by the action of water turbulence. The distinctive feature of this stage is that the influence of gravity is small, and the oil spill spreads under the interaction of oil and water [6].

The fourth stage, longitudinal drift.

When the oil spilled was approximately uniformly mixed on the cross section, the oil spilled into the longitudinal drift stage. At this stage, the dispersion along the longitudinal direction is dominant, and the longitudinal drift characteristics of a specific oil product are mainly affected by factors such as water flow speed, wind speed, and channel topography.

In the fifth stage, the section expands under the action of the oil boom.

When the oil spill drifts to the arranged oil blocking facilities, it is intercepted by the oil boom, and the longitudinal speed is limited, and it spreads to both sides along the oil boom and the direction of the water flow (generally arranged obliquely) [7]; if it is not collected in time Oil, as the oil spills accumulate here for a period of time, the vertical diffusion behavior of the oil spill is strengthened, and the oil spill may escape from the bottom of the oil boom skirt; when the water flow speed is high, the oil spill may also Splash escape above the oil boom.

## 3. Conclusion

(1) Among the five stages of oil spill migration and diffusion, stage 1 and stage 2 will be carried out a few minutes or less before the oil spill occurs. The oil spill migration behavior in these two stages is microscopic and will affect the crossing pipeline. Chain reactions such as leakage accidents, fires and explosions in the vicinity of the leakage point are related to the prediction, prevention and control of the short-term consequences of the accident.

(2) The third stage and the fifth stage are the expansion of the oil spill turbulent cross-section, which is related to the river topography, hydrological characteristics and the obstruction of the oil spill. Analysis of oil spill turbulence behavior From the perspectives of micro (vertical) and macro (horizontal, the vertical mixing distance of oil and water is much smaller than the width of the river channel), analyze the free turbulent diffusion of oil spill and the turbulent diffusion behavior under the action of the oil boom, which is a favorable interception point and The

design of an effective oil interception scheme provides a basis and is one of the foundations of oil spill emergency response.

(3) The fourth stage, the longitudinal drift stage, refers to the spread of oil spills along the direction of water flow. The temporal and spatial distribution of oil spills is analyzed from a macro perspective. Since the longitudinal distance of the river is much larger than the width, this stage can be regarded as a one-dimensional longitudinal Look at the problem of dispersion. Longitudinal drift behavior can provide the time-varying position of the oil head, thereby indicating the effective geographic interval for oil spill interception, and is also an important part of oil spill emergency response work.

(4) In these five stages, the oil spill diffusion types include molecular diffusion and turbulent diffusion with water flow. Since the specific gravity of crude oil is lighter than that of water and the solubility in water is small, the molecular diffusion effect is very small. Ignore, here mainly consider the influence of turbulent diffusion.

(5) In fact, except for the first stage, the diffusion of crude oil in the river is three-dimensional, but the characteristics of each stage are different: the second stage oil spills floating up, which can be seen as vertical turbulent mixing of continuous point sources. ; the third stage is the lateral turbulent mixing of continuous point sources; the fourth stage, the vertical diffusion behavior is prominent, the lateral and vertical turbulence can be ignored, this stage can be simplified as one-dimensional longitudinal turbulent diffusion; the fifth stage, The vertical diffusion of the oil spill is hindered, mainly manifested in vertical turbulent mixing and lateral turbulent mixing, but different from the second and third stages, the oil spill in this stage has already appeared as a thin body on the water surface before contacting the oil boom, with a certain thickness and width, since the thickness is small compared to the width, it can be regarded as a turbulent mixing problem for continuous line sources. The first, second and third stages are very short, mainly mixing oil and water, the distance is short, and the impact on the decision of oil spill interception is not large, so the paper mainly analyzes the turbulent diffusion behavior of oil spill in the fourth and fifth stages.

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