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Third-party Damage Analysis and Intelligent Risk Management Research in High-Consequence Areas of Oil and Gas Pipelines

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Abstract

With the country's continued expansion of the scale of oil and gas pipelines, the continuous expansion of pipeline service life, and the increasing safety and environmental risks of pipeline companies, more and more attention is paid to pipeline integrity and safety management, and pipelines in service pass through densely populated areas and environmentally sensitive areas. Areas, once leaks, fires and explosions occur, serious safety hazards such as serious casualties, environmental damage, water pollution, etc. will occur. This article will conduct an in-depth study on the definition of third-party damage in high-consequence areas of oil and gas pipelines and high-consequence for oil and gas pipelines. The district third-party destruction management and control intelligent ideas and concepts are expanded.

Keywords

Risk Management and Control; High-Consequence Area; Risk Assessment; Intelligent.

1. Introduction

With the continuous development of science and technology in my country, the demand for oil and gas resources is increasing. In order to ensure the safe transportation of oil and gas resources, the fast-growing oil and gas industry needs the strong support of intelligent risk prediction systems and efficient and advanced safety management and control technologies[1-3]. The oil and gas industry, as the most important traditional heavy industry in China, needs to keep pace with the times[4], and increasingly tends to be intelligent and informatized. For the risk management of oil and gas pipelines, there are about 30 years of analysis around the world[5], and it has achieved relatively ideal achievements. In the relevant transformation and transition work[6], it has gradually developed more standardized and professional system[7]. Therefore, how to use emerging technologies to achieve accurate prediction of third-party damage scenarios and intelligent and efficient risk management in high-consequence areas of oil and gas pipelines is an important topic we have to solve today[8]. This article will describe the definition of third-party damage in high-consequence areas, and put forward an intelligent management idea for high-pressure oil and gas pipelines in combination with new technologies. Therefore, in practical applications, it is possible to realize safer and more efficient early warning management and control of oil and gas pipeline risks.

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2. Definition of Third-Party Sabotage in High-consequence Areas of Oil and Gas Pipelines

2.1 Features and Characteristics of High-Flight Zone

The high-consequence areas that define oil and gas pipelines are high-consequence areas in areas where the population density is relatively large, or the economically developed areas such as dense constructions[9]. These areas generally have large markets, public transportation facilities, high-rise buildings, hospitals, schools, nursing homes, or other construction facilities that are difficult to evacuate. According to the in-depth study and understanding of the high-consequence areas in the actual production and life of oil and gas pipelines[10], the high-consequence areas of oil and gas pipelines have the following characteristics as shown in Table 1:

Table 1. Characteristics of high-consequence areas of oil and gas pipelines

Serial number	Characteristic description	distributed
1	High population density	Residential area
2	Building concentration	Factory, residential area
3	Specific natural environment	Environmental protection zone, water source
4	Flammable and explosive dangerous places	Gas station
5	Engineering construction of important railways, highways and bridges	Important traffic section
6	Some areas where pipelines are located are economically developed	Cables, water pipes, pipelines dense areas

As the population and environmental resources change over time, the geographic location and scope of the high-consequence zone will also change accordingly[11]. Therefore, we need to define clear standards for the high-consequence zone of the pipeline. The division of high-response areas is now mostly based on the high-response area identification grading table, as shown in Table 2 and Table 3.

Table 2. Identification classification table of high consequence area of oil pipeline

Pipe type	Identification item	Grade
Oil pipeline	Within 200m of the pipeline centerline, arbitrarily divide a number of sections with a length of 2km that can contain the largest number of households, and sections with four or more floors (excluding basement floors) generally concentrated, frequent traffic, and many underground facilities.	III
	Within 200m of the pipeline centerline, arbitrarily divide a number of sections with a length of 2km and contain the largest number of households, and sections with more than 100 households, including suburban residential areas, commercial areas, industrial areas, development areas, and areas less than four levels Conditional demographic area	II
	There are villages, towns, etc. with 50 households or more within 200m on each side of the pipeline	II
	There are expressways, highways, provincial highways, railways and flammable and explosive places within 50m on both sides of the pipeline	I
	There are wetlands, forests, estuaries and other national nature reserves within 200m on both sides of the pipeline	II
	There are water sources, rivers, and large and medium-sized reservoirs at 200m on each side of the pipeline	III

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Table 3. Classification table for identification of high-consequence areas of gas pipelines

Pipe type	Identification item	Grade
Gas pipeline	The four-level area that the pipeline passes through, the regional level shall be implemented in accordance with the relevant regulations in GB50251	III
	Tertiary areas where the pipeline passes	II
	If the pipe diameter is greater than 762mm, and the maximum allowable operating pressure is greater than 6.9MPa, the potential impact area of the natural gas pipeline has a specific location in the area, and the potential impact radius is calculated according to the formula	II
	If the pipe diameter is less than 273mm, and the maximum allowable operating pressure is less than 1.6MPa, the potential impact area of the natural gas pipeline has a specific location in the area, and the potential impact radius is calculated according to the formula.	I
	Other areas with specific places within 200m on each side of the pipeline	I
	Except for Grade 3 and Grade 4 areas, there are gas stations, oil depots and other flammable and explosive places within 200m on each side of the pipeline	II

Based on the understanding of the above characteristics, combined with the characteristics of high-consequence areas, the identification factors of high-consequence areas are defined as the four main factors of population density, dangerous structures, special natural environment, and economic impact.

2.2 Definition of Third-Party Damage

In oil companies, third-party sabotage refers to accidental damage to the pipeline caused by the actions of non-pipeline employees. Third-party damage of oil and gas pipelines does not refer to the deliberate damage of the pipeline by a third party, but refers to the damage of the pipeline caused by the third party's ignorance of the precise location of the underground pipeline or the ignorance of the danger of the pipeline during other activities[12]. Third-party damage is defined in the scope of man-made unintentional damage and natural disaster damage, and man-made deliberate damage does not fall within this scope. Pipeline designers and managers can influence the risks caused by third-party sabotage. The degree of activity on the ground, the difficulty of the intruder's approach to the pipeline, and the possible intrusive factors around the pipeline have an impact on the possibility of damage to the oil and gas pipeline by a third party. Possible intrusive factors include: various excavation equipment, shooting devices, motor vehicle passages, trains, agricultural machinery, seismic effects, fence posts, telephone lines and wire posts, anchors, and river dredging machinery. The factors that affect the difficulty of the intruder's access to the pipeline are: the thickness of the covering layer, the nature of the covering layer (soil, stones, concrete, pavement, etc.), man-made obstacles (fences, dams, ditches, civil defense works, etc.), natural obstacles (Trees, rivers, rocks, river ditches, etc.), whether there are pipeline signs, the status of road rights, the frequency, method and quality of line inspections, and the response time when there is a threat to the report. The degree of activity on the ground mainly depends on: population density, nearby construction activities, the proximity and throughput of trains or motor vehicles, the area where ships are anchored, communication conditions, and the number of underground installations in the area.

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3. Difficulties in The Prevention and Control of Third-Party Damage

3.1 Risk Early Warning is Difficult

Oil and gas pipelines have a vast span of service, a wide spread area and complex humanities. The illegal construction in the oil and gas pipeline work area, the poor awareness of the engineering vehicle drivers to protect the pipeline facilities, operation errors can easily cause third-party damage, and in some areas oil theft incidents One after another, unknown natural disasters have spread to pipelines, causing pipeline damage, etc. Such a large number of factors make it difficult to predict before the accident occurs.

3.2 Difficult to Troubleshoot

Geological disasters such as earthquakes, landslides, etc. occurred, oil and gas pipelines were destroyed, and the accident site was buried. Brutal construction and unpredictable acts of stealing oil are most likely to cause damage to oil and gas pipelines. However, some of the perpetrators destroyed the accident site in order to evade responsibility, making it difficult to investigate the accident site and delaying emergency repairs.

3.3 High Investment in Human and Material Resources

Oil and gas pipelines span a vast area, and the natural environment and geological conditions are complex and diverse. Because most of the oil and gas pipelines are laid in the open air, they are damaged by natural disasters from time to time. However, due to the vast area and sparsely populated areas, the exact location of the accident depends on manual investigation Difficulties.

4. Pipeline Multi-Pole Three-Dimensional Intelligent Video Thied-Party Damage Prevention and Control System

In view of the above difficulties in the prevention and control of third-party damage, a multi-pole three-dimensional intelligent video third-party damage prevention and control early warning system for oil and gas pipelines can be proposed. This program has the following characteristics in the application of third-party damage prevention and control of high-pressure oil and gas pipelines:

4.1 Intelligent Judgment, Multi-Pole Warning

The system places smart cameras in the key monitoring areas of high-consequence areas of oil and gas pipelines, and can monitor whether there are over-limit and ultra-high dangerous operations of construction machinery in the oil and gas pipeline working areas. At the same time, it also conducts intelligent assessment of man-made sabotage behaviors. The smart camera uses smart face recognition technology and connects the data center with the local public security bureau. For illegal third-party sabotage behaviors, the scene can provide timely and multi-channel sound and light alarms and automatic remote Alarm (upload text and forensic pictures in time). Monitoring scope: in a space with a depth of 300 meters, a width of 50 meters, and a height of 40 meters, the information of construction equipment, vehicles and personnel can be detected, intelligent determination of illegal work equipment and personnel behavior, multi-level early warning, and realization of oil and gas pipelines Blind-angle visual development.

4.2 Dynamic and Static Linkage, Continuous Monitoring

The system equipment is equipped with various information modules such as wireless communication, embedded system, image compression and intelligent cloud recognition algorithm, DSP, etc. In addition to the monitoring of fixed monitoring points, it also dispatches drones equipped with smart cameras for 24-hour normalization Dynamic line patrol monitoring, the fixed camera of the monitoring point and drone monitoring are combined, dynamic and static are combined, real-time feedback information to the rear monitoring center, and the monitoring center then diversifies the monitoring information to the Internet platform, and the staff can view it through the mobile computer APP On-site real-time photos, no matter where the staff is, they can obtain the monitoring site

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information they are concerned about anytime and anywhere, which greatly improves the monitoring efficiency and accuracy, and reduces the capital investment.

4.3 Multi-Party Monitoring, Intelligent Voice Alarm

All monitoring and detection are automatically completed at the front end, and information is sent to the monitoring center when there is an early warning or warning. The intelligent detection system can monitor and detect multiple construction machinery at the same time. It is also equipped with multiple sets of voice alarms. The main alarm device is installed at the monitoring points of the oil and gas pipeline high-consequence area and the drone. When the intelligent monitoring system finds and recognizes the first For tripartite sabotage, immediately upload the alarm information to the staff's mobile phone or computer, and then issue a voice warning and drive away.

4.4 Outstanding Comprehensive Adaptability and Excellent Performance

The system has strong network compatibility and can be adapted to and connected to various media Internet platforms; and the system has anti-theft function. Once the front-end equipment is anti-theft, the system can actively send an alarm to the monitoring center. At the same time, it also has the equipment fault diagnosis function; if the front-end equipment is damaged and cannot be monitored normally, such as insufficient power, image quality problems, image obstruction, etc., it will also send an alarm to the background (separate configuration according to user needs).

5. Conclusion

(1) Through the definition of third-party damage risk management and control of high-consequence areas of oil and gas pipelines, clear standards have been defined for the high-consequence areas of oil and gas pipelines, and combined with the characteristics of high-consequence areas, the identification factors of high-consequence areas are defined as population density, Dangerous structures, special natural environment, and economic impacts are four major factors.

(2) Aiming at the problems of difficulty in early warning, difficulty in investigation, and large investment in human and material resources in the prevention and control of third-party damage in high-consequence areas of oil and gas pipelines, a multi-polar three-dimensional intelligent video third-party damage prevention and control system for oil and gas pipelines was proposed to create a "oil and gas pipeline visualization network". Apply line intelligent inspection system, promote user information management and control platform "intelligent pipeline prevention and control mode, realize the transformation of oil and gas pipeline prevention and control from "human defense" to "technical defense", and achieve the goal of efficient and intelligent management of oil and gas pipeline safety management and control.

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