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Fire risk analysis and prevention of urban comprehensive pipeline corridor

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Abstract

More and more comprehensive pipeline corridors are built in the urban cities to avoid the inconvenience effects of traffic jams to people's daily lives that pipelines laying caused and raise the quantity of pipeline management. While, the fire risk degree of comprehensive pipeline corridor is pretty high. This article analyses the fire risk type and characteristics in comprehensive pipeline corridor and discuss some fire safety prevention methods to reduce the loss that fire causes, such as fire partition design, structure material replace, automatic fire detective and extinguish system. High expansion foam system is suggested to be used in the comprehensive pipeline corridor for its low water use and high fire extinguish effect. The water use amount of high expansion foam system and normal water sprinkle system are compared. This advantage of high expansion system also means that the post-disaster recovery efforts are much less than that of normal water sprinkle system.

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Keywords: comprehensive pipeline corridor; fire risk analysis; high expansion foam system.

Nomenclature

V	flooded volume
R	bubble minimum supply rate
C_N	bubble compensation coefficient
C_L	bubble leaked compensation coefficient
t	time
r	foaming rate
q_h	bubble mixture flow rate
K	high expansion foam mixture liquid mixing ratio
N	required amount of foam generator
Q_h	bubble mixture required flow rate
Q_p	total amount of foam mixture liquid

1. Introduction

As the economy developing constantly, most pipelines can no longer fulfill the demands of people. In order to check the integrity of pipelines, replace the low-capacity pipelines of high-capacity pipelines, maintain and repair the pipelines

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regularly, we need to excavate into deep underground at the same location repetitively, which cause traffic jams and inconvenience to people's daily lives. For that reason, urban comprehensive pipeline corridor has been applied in the city municipal construction projects.

The first comprehensive pipeline corridor appeared in France. In 1983, for improving the city environment, Paris set a pipeline corridor to locate a grand scale of sewage network under the city roads, the maximum section area of which was 6 m high and 5 m width. The comprehensive pipeline corridor contained water pipeline, communications pipeline and compression air pipeline, traffic communications cable and many other public facilities, formed the first complete comprehensive pipeline corridor. Since then, England, Germany, Japan, former Soviet Union and Spain also set up comprehensive pipeline corridor in succession.

Urban comprehensive pipeline corridor contains all the systems that are essential for the daily life, such as electric power, water supply and drainage, telecommunications, gas, heat and other pipelines in one underground centralized tunnel. The comprehensive pipeline corridor also has its separate system of drainage, lighting, communication, monitoring and other facilities. While because of its high concentration of pipelines, particularly the electricity and gas pipelines putting in one corridor, the comprehensive pipeline corridor is facing serious fire security problems. Ming-hua Hu [1] proposed that natural gas leaked and dispersed in the pipeline corridor would cause fire incident, thus fire automatic detectors and alarm devices are required in order to discover early-stage fire as soon as possible. Tong-ming Wang [2] analyzed the risk of fire including fire and gas explosion in the comprehensive pipeline corridor, and suggested that fire partition are needed in the corridor to prevent fire expanding which may cause large scale partial damage. Yu Sun [3] discussed the fire resistance ability of structure in the comprehensive pipeline corridor under the fire condition, and put forward that automatic sprinkler system can be applied in the pipeline corridor fire for early-stage fire extinguishment. Hao Zhang [4] put forward that fire safety design need to combine with the comprehensive pipeline corridor function, safe operation and electrical power system target. He also used a comprehensive pipeline corridor near the Tai Lake in Wuxi as example. Xin-yi Chai [5] introduced the fire safety design in the comprehensive pipeline corridor along Zhangyang Road in Shanghai, including its necessity and feasibility and a brief description of the water atomizer provided therein for fire control. Li-dong Wang [6] discussed the importance of ventilation and smoke exhaustion system in the comprehensive pipeline corridor, and suggested ventilation, alarm system and fire-fighting system should cooperate with each other.

This paper discusses the fire risks in the comprehensive pipeline corridor, including the fire types and causes, fire characteristics and fire loss analysis, then provides references for the fire-safe design of the comprehensive pipeline corridor.

2. Fire risk analysis of comprehensive pipeline corridor

2.1. Fire types and causes

There are many electrical equipment and cable wires in the comprehensive pipeline corridor, which may lead to electrical fire. If gas pipe is also contained in the pipeline corridor, it may also initiate C type fire or explosion because of gas leaking. Sewage that flows in the drainage pipe may give off combustible gas which may cause C type fire too. The material of insulating layers and shield layers for hot water pipes and air-conditioner pipes are easy to burn, which may cause A type fire. Besides, when maintainers go down into the pipeline corridor to do the routine maintenance and management, they may bring some combustible materials and objects, which may cause A type fire or B type fire.

In case of large quantities of combustible objects existing in the comprehensive pipeline corridor, fire may break out once the temperature arrives threshold. There are several reasons for the temperature raise in the comprehensive pipeline corridor: first, ventilation system design is not reasonable or some malfunction occurs may lead to the poor ventilation, then heat dissipation is delayed which leads to temperature raise; second, the electrical wire may get on fire itself for phase fault, earthing short circuit, poor electrical connection, wire line overload or other reasons; third, maintainers may cause open fire or other kind fire source by incident or on propose.

The comprehensive pipeline corridor has mechanical ventilation system or natural ventilation vents for heat dissipation and air blowing, which provides oxygen for combustion, thus the fire risk of comprehensive pipeline corridor is high.

2.2. Fire characteristics

(1) The fire in the comprehensive pipeline corridor develops rapidly and easily expand

The corridor is a long, narrow, tube-like construction with few partition inside it, and the electrical wires the corridor contains are arranged centralized. When the fire breaks out, fire will spread to adjacent place through the wires, as the wires has lots of combustible insulation covers, the fire may expand.

(2) Fire will produce lots of high-temperature smoke, the corridor may occur smolder and backdraught