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Application of Intelligent Monitoring System to the Long-Distance Oil and Gas Pipeline in PetroChina Southwest Pipeline

Haijian Zhang
Natural Gas Stations of West East Gas Transmission Branch of National Pipe Network Group United Pipeline Co., Ltd., Jingyuan city, Gansu, China

Abstract:

Long-distance oil and gas pipeline is an important way of energy transportation, and its safety management is the top priority for pipeline companies. With the development of intelligent technology and communication technology, intelligent monitoring and management of oil and gas pipelines have become possible. Likewise, this paper comprehensively introduces an application of intelligent monitoring system to the long-distance oil and gas pipelines in PetroChina southwest petroleum, and analyzes the important role of intelligent systems in the safety management of long-distance pipelines.

Keywords: *Long-distance oil and gas pipeline, Cathodic protection, Intelligent monitoring.*

I. INTRODUCTION

In petroleum and natural gas industries, pipeline transportation, as one of the five major transportation modes, has developed rapidly worldwide. Especially, in the developed countries, crude oil pipeline transportation has accounted for more than 80% of the total transportation volume, while the natural gas pipeline transportation has accounted for more than 95% of the total transportation volume. According to the statistics of 2015, total mileage of the global oil and gas pipelines has reached 20.58 million kilometers [1]. It is estimated that by 2025, China's oil and gas pipeline network will reach 240,000 kilometers [2]. The development of oil and gas long-distance pipeline in China has been more than 50 years, and most pipelines have reached the middle and late service stages. For these complex pipe network systems across the country, the transported oil and gas leakage caused by pipeline damage will cause a huge damage. Some scholars estimate that more than 70% of the developed oil and gas fields in the world are highly susceptible to corrosion. The annual losses caused by the corrosion problems account for more than 45% of the total losses in oil, gas and petrochemical industries. Therefore, pipeline

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corrosion is an extremely important factor to consider, for the safe operation of pipelines [3].

The control of pipeline corrosion is one of the means for maximizing the benefits of pipeline transportation companies. China has formulated laws, regulations and standards on pipeline safety, for regulating the pipeline transportation, ensuring pipeline safety, and reducing the losses caused by accidents. However, pipeline laws and regulations must be established based on the pipeline inspection data. Therefore, it is particularly important to establish a comprehensive management system for pipeline corrosion and protection detection, monitoring, inspection and maintenance. Its successful operation will provide a powerful means for pipeline safety management.

II. THREATS TO LONG-DISTANCE OIL AND GAS PIPELINES

Buried pipelines correspond to the largest steel components buried underground. With a length of up to thousands of kilometers, these pipelines can pass through different types of soil, different ecological environments, different economic development regions, and even different countries. The soil, temperature, groundwater and stray current along the pipeline lead to pipeline complex external environment. Chemical corrosion, electrochemical corrosion, electrical corrosion, and physical damage constantly lead to the premature failure of buried pipelines, thereby inducing oil, gas, and water leakage losses, waste of materials and manpower due to maintenance, and losses caused by shutdowns and production. In addition, even serious consequences, such as oil and gas fires and explosions, which seriously threaten the personnel safety and pollute the environment, have continued to appear in the newspapers [4].

The corrosive media for buried long-distance pipelines include soil, atmosphere, water, and so on. When the covering layer for buried pipeline fails, pipeline material is directly exposed to various corrosive media, originating danger of media corrosion. Soil is a complex system consisting of gas, liquid and solid. Besides, water and air can be found in the soil. When the salt dissolves in water, the soil becomes an electrolyte. Unlike the fluid nature of atmosphere and seawater, the solid components that make up the soil are relatively fixed, and therefore, even soils of the same type have different physical and chemical properties. By taking the heterogeneity of the soil into consideration, the corrosiveness in the same kind of soil is not the same. Thus, soil corrosivity indicates a very complicated problem.

The long-distance pipeline possesses a long buried-distance and a complex environment. In addition to chemical and electrochemical corrosion in the medium environment, it is also prone to macroscopic battery corrosion. The cathode and anode of the macro battery corrosion are far

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apart, and the distance between corrosion area and protection area on a long-distance pipeline is often up to several kilometers. The causes of macroscopic battery corrosion mainly include oxygen concentration corrosion, salt concentration corrosion, temperature difference corrosion and stress difference corrosion. Owing to the structural characteristics of long-distance pipeline and the buried environmental complexity, macro battery corrosion cannot be ignored in pipeline corrosion. The macroscopic battery corrosion rate is often much greater than the microscopic corrosion rate of pipeline surface, causing too fast local corrosion of pipelines quickly and advanced failure.

In addition, long-distance buried pipelines may be corroded by the stray current. Stray current generally comes from the electric power systems with rails as conductors, DC power distribution systems, factory welding systems, city telephone systems, cathodic protection systems, and AC high-voltage power systems etc. When insulation performance of the power supply is poor or the current source has a directly grounded part, the current leaking from the power supply will flow into the long-distance pipeline through an electrolyte, then flow out from other parts of the pipeline, and finally return to the other end of the power supply. Moreover, when an electric current flows in the metal, a violent corrosion process will occur at the current outflow part [5-7]. This kind of corrosion is usually called as stray current interference corrosion or electric corrosion for short.

III. APPLICATION OF PETROCHINA SOUTHWEST PIPELINE INTELLIGENT MONITORING SYSTEM

With the continuous technological advancements, the pipeline safety management has progressed from rugged to refined. Digital pipeline and pipeline integrity management make it possible to fully grasp the pipeline safety factors, and fully control the safety risks. Based on the traditional decentralized management of pipeline technology, equipment and protection measures, the pipeline risk parameters are digitized, platformized and real-time. The purpose of research and development of the emerging pipeline intelligent monitoring system is to fully integrate the pipeline risk factors with the GIS, Internet of Things (IoT), and other emerging technologies. Comprehensive integration of pipeline risk factors, mainly including soil, water, atmospheric corrosion, stray current, cathodic protection, and pipeline corrosion rate, can achieve the pipeline risk management and control and guarantee pipeline operation safety.

Chongqing Gas Mine of PetroChina southwest oil and gas field has more than 20,000 kilometers of gas gathering and transportation pipelines. Besides, the cathodic protection facilities are relatively complete but the system lacks in managing cathodic protection related data, comprehensive analysis, and decision-making. Since 2018, the southwest pipeline has

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begun to build a comprehensive cathodic protection management platform that can be continuously integrated to realize a comprehensive cathodic protection data management platform for cathodic protection related cathodic protection design, facilities and equipment, monitoring data, inspection of data, and manual inspections. The intelligent monitoring system can realize the data access and synchronization, and can be compatible with different cathodic protections. Modeling and comprehensive analysis of pipeline design parameters for cathodic protection, cathodic protection monitoring data, stray interference, pipeline monitoring data, and pipeline corrosion accident records etc., are used to evaluate the pipeline cathodic protection. An advanced intelligent regulation and decision support system based on big data is provided to support the comprehensive evaluation and risk control of pipeline cathodic protection.

Simultaneously, a pipeline cathodic protection and stray current intelligent monitoring terminal were deployed in the Jiangjin-Tongliang pipe section of Zhonggui line of the southwest pipeline as the data collection support for system platform, to realize pipeline cathodic protection status monitoring, cathodic protection equipment remote control, pipeline stray current monitoring, pipeline safety early warning, and other functions. This study can lay a foundation for the realization of pipeline digitization, risk, intelligent management.

3.1 Composition of Intelligent Monitoring Management Platform

The pipeline management refers to managing the pipeline information. The integrated management platform will collect, manage, analyze and make intelligent decisions on the pipeline information, safety information, corrosion and anti-corrosion information closely related to the pipeline, and the continuously changing state information of the pipeline. This ensures the rapid response and quick decision on pipeline information, further guaranteeing the safe operation of pipeline.

The construction contents of the intelligent monitoring integrated management platform include:

(1) Basic data integration.

(2) Centralized control and management of intelligent monitoring piles.

(3) Intelligent adjustment of cathodic protection.

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(4) Centralized and unified basic data management.

(5) Comprehensive analysis and modeling of cathodic protection.

(6) Intelligent decision for cathodic protection.

The overall structure of the integrated management platform for intelligent monitoring of oil and gas pipeline is shown in Figure 1. The system platform consists of five independent application software and a set of norms and standards.

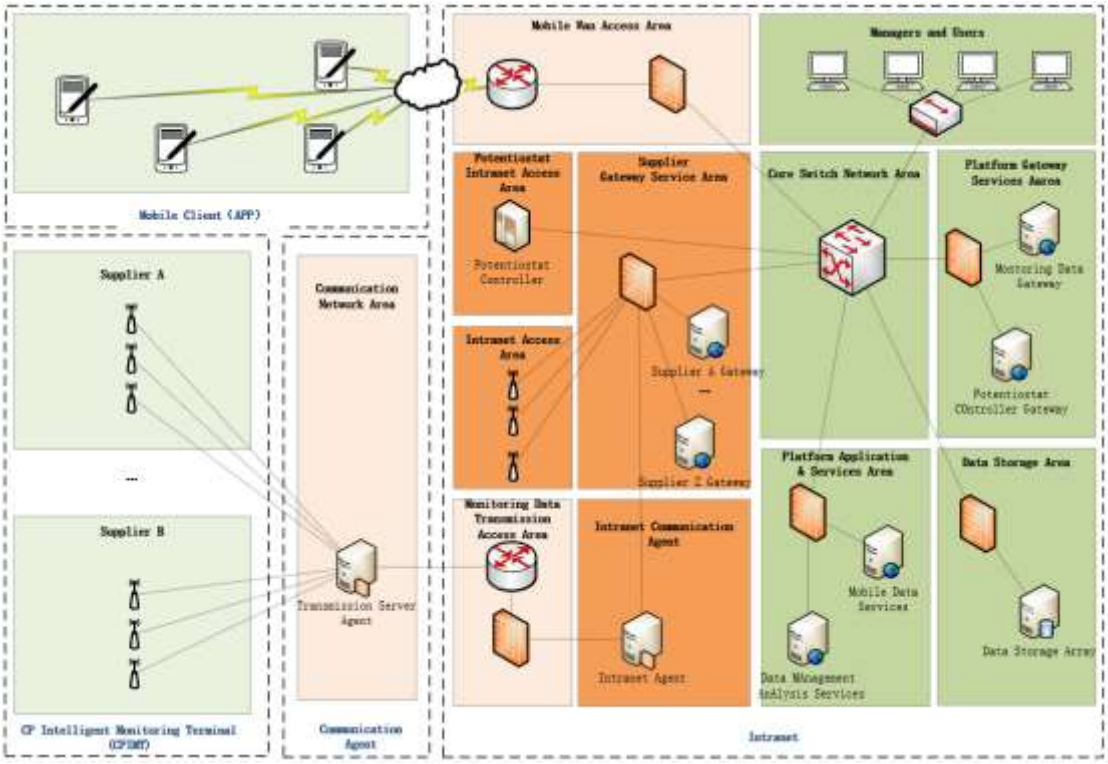

Fig 1: The overall structure of the integrated management platform for intelligent monitoring of oil and gas pipeline

3.2 Intelligent Monitoring Management System Functions

Cathodic protection integrated management platform is a centralized and unified monitoring management platform, which can also p a unified entrance for all related management personnel to query, analyze, and display the cathodic protection data. The relevant functions and advantages are as follows:

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(1) The intelligent monitoring system can simultaneously monitor the on or off potential, DC or AC current density, pipeline corrosion rate, and stray current status of pipeline cathodic protection etc. Manually measuring these data at the same time is time-consuming, labor-intensive, and error-prone.

(2) Pipeline vibration and image data can be uploaded in real time, to monitor the condition of drilling and stealing oil, mudslides, artificial destruction, and other serious impacts on pipeline safety, effectively.

(3) The potentiostat can be used for remotely adjusting overall potential through the pipelines, hence achieving a more intelligent big data regulation pipelines full cathodic protection status.

(4) Synchronous monitoring of continuous pipeline potential can assist in effectively mastering the interference status of stray current received by the pipeline, to judge the interference sources more effectively, and develop efficient solutions.

(5) The system can provide real and effective data support for the big data comprehensive analysis of the management system platform and expert system.

The system module structure of the integrated management platform for intelligent monitoring of long-distance oil and gas pipeline is shown in Figure 2.

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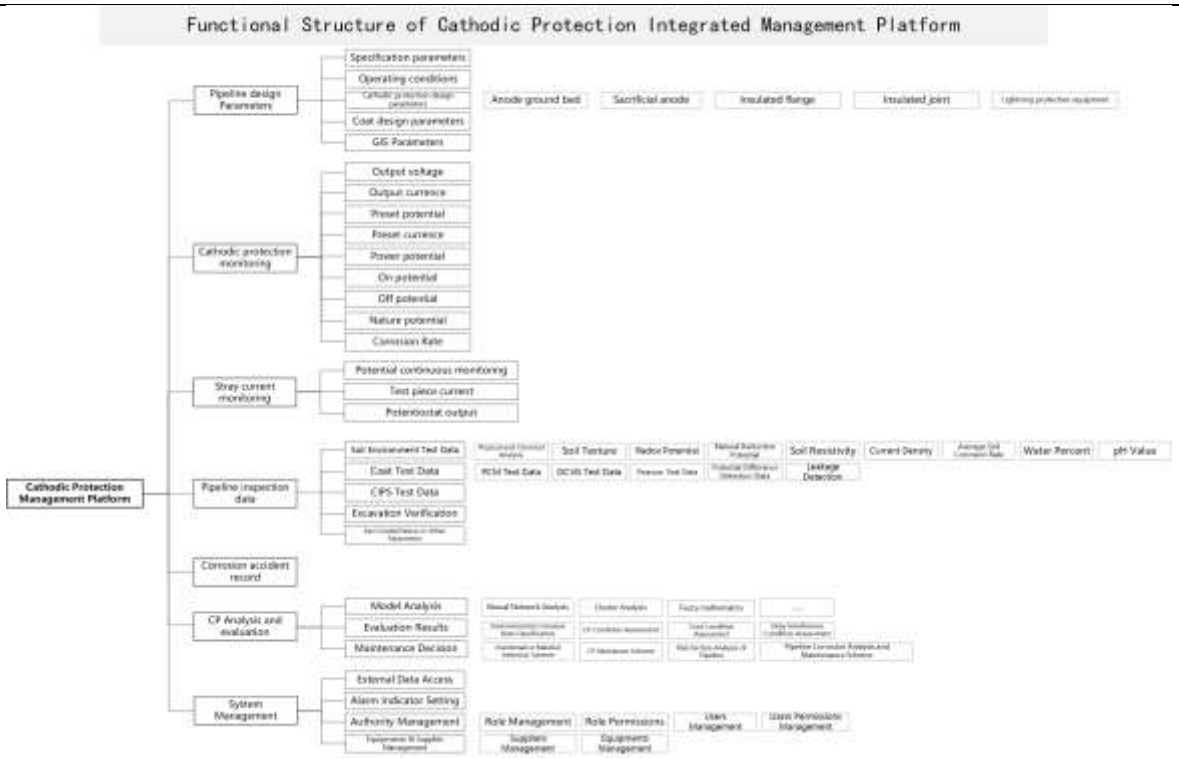

Fig 2: The system module structure of the integrated management platform for intelligent monitoring of long-distance oil and gas pipelines

3.3 A case Study of Intelligent Monitoring Management System

Through the intelligent test pile, the pipeline cathodic protection status can be discovered and warned in time, and relevant decision-making plans can be put forward. The Figure 3 demonstrates the pipeline on/off potential curve monitored continuously by the monitoring system at Zhonggui line pipe section. It can be seen that the pipe section is disturbed by the typical dynamic stray current, which causes the pipeline potential to fluctuate. According to the survey of electric facilities near the pipe section, it can be concluded that the stray current source is the electric equipment near the pipe. For the unknown stray current interference sources, intelligent monitoring terminal can adopt ultra-high frequency monitoring mode to measure and judge the frequency interference of stray current. Likewise, Figure 4 is the analysis curve of potential frequency interference at the Zhonggui line pipeline section. It can be observed that in addition to being interfered by DC stray current, the pipeline is also interfered by AC current with a frequency of 64 Hz.

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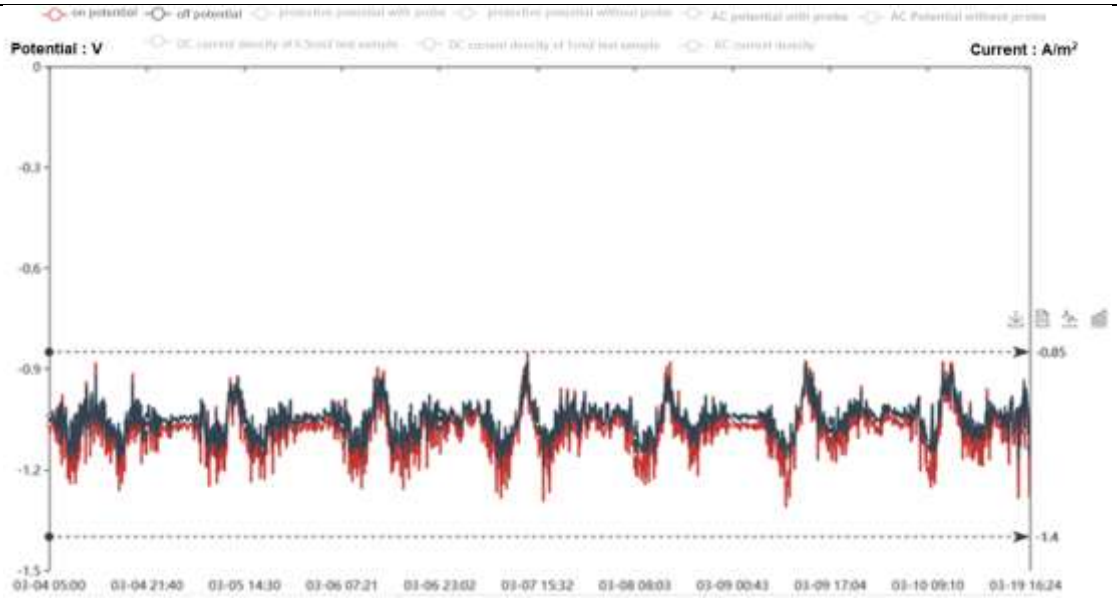

Fig 3: Monitoring results of Zhonggui Line cathodic protection potential

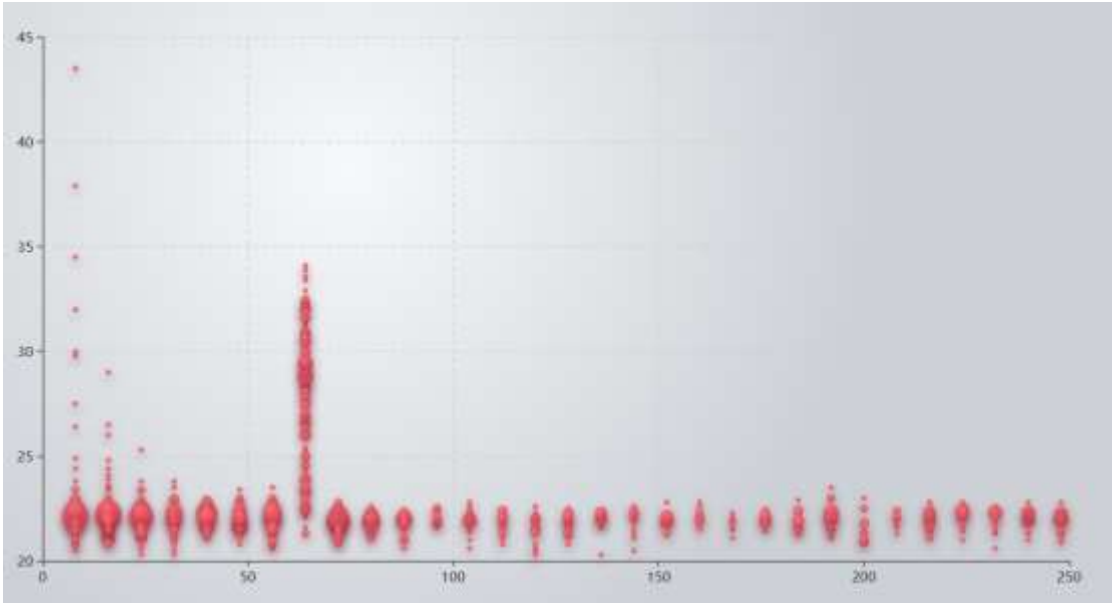

Fig: 4 Frequency interference curve of stray current in pipe section

IV. CONCLUSION

The intelligent monitoring and management system for the long-distance oil and gas pipelines can timely discover pipeline environmental corrosion risks, analyze and judge the

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risks sources, and provide decision-making basis for pipeline managers. By digitizing the pipeline information, powerful technical support can be provided for the safe operation of pipelines.

REFERENCES

[1] YAN L (2017). The distribution status and development trend of global oil &gas pipelines, Oil &Gas Storage and Transportation, 36(5).
[2] National development and reform commission, midia and long range planning of oil and gas network.
[3] SUN N, WANG HM (1999). Corrosion problems and Countermeasures in oil and gas production and transportation, National Corrosion Control Conference Proceeding in China.
[4] Chinedu IO (July 2015), Pipeline failures in corrosive environments- A conceptual analysis of trends and effects, Engineering Failure Analysis, 53: 36-58.
[5] Schwalm LH, Sandor JG. Stray current – the major cause of underground plant corrosion, Materials Perform, 1969(6).
[6] Bertolini L, Carsana M, Pedeferri P. Corrosion behavior of steel in concrete in the presence of stray current. Corrosion Science, 2007(49).
[7] Evin SI, Kharionovsky VV (1993). Causes and frequency of failures on gas mains in the USSR pipe. Pipelines International, 26(4).