Causes of Natural Gas Pipeline Leakage and Detection Methods

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Abstract

With the continuous development of modern science and technology and the improvement of the economic and social modernization process, the continuous improvement of the material, spiritual and cultural living standards of the public requires the construction of urban infrastructure to be more effective and perfect. As the main carrier of Z for natural gas transmission, natural gas pipelines have always had extremely strict requirements on the tightness of the pipeline. Once the airtightness of the natural gas pipeline is poor and leakage occurs, when the natural gas comes into contact with various external variables, it may cause various large-scale vicious accidents and cause serious losses. For this reason, timely and accurate detection of leakage problems in natural gas pipelines, and clarification of specific leakage locations and leakage conditions are particularly critical for preventing potential safety hazards in natural gas pipelines. This article does a detailed analysis and explanation of this problem.

Keywords

Natural gas pipeline, Type of leak, Cause of leak, Leak detection.

1. Phenomenon Analysis of Natural Gas Pipeline Leakage

With the support of the current technical conditions, whether the natural gas pipeline will leak is not only related to the quality of the natural gas pipeline itself, but also has a significant correlation with the surrounding environment.

1.1 Areas where Natural Gas Pipelines Often Leak

Based on practical work experience, the areas where natural gas pipelines often leak are as follows:

(1) Connection part;

(2) Scoured parts;

(3) Filler parts.

Since the area where the natural gas pipeline is laid is a saline-alkali area, the corrosion problem is extremely serious. Therefore, if the corrosion resistance treatment of the natural gas pipeline cannot be done in time, it is likely to cause serious natural gas leakage problems in some highly corroded areas. At the same time, from a management point of view, although the dynamic supervision and management along the natural gas pipeline is done well, there is still the problem of "punching and stealing gas", which not only causes the loss of economic benefits, but also potentially a large number of Potential safety hazard, natural gas leakage is shown in Figure 1.

Figure 1: Leakage of natural gas pipeline

1.2 Types of Common Leaks

The equipment in general natural gas metering stations mainly includes separators (both vertical and horizontal), receiving and sending cylinders, valves (including: ball valves, stopcock valves, gate valves, etc.), gas collecting pipes, and pipelines (mainly normal export Pipelines, venting pipelines, sewage pipelines, etc.). Others such as transmitters (temperature transmitters, pressure transmitters, etc.), pigging ball passing indicators, temperature gauges, pressure gauges, etc. So the leaks are also generated from these devices. The connection forms between these equipment and instruments and meters are mainly flange connection, welding and threaded connection. In natural gas stations, the most common location for gas leakage is at static sealing points, such as flanges and threaded joints. However, pipeline perforation and leakage also occur from time to time, mainly at pipeline elbows, especially the bends of sewage and venting pipelines. At the top, the most common leaks on the line are caused by third-party damage and pipe perforations. According to the actual situation on site, I concluded that the common leaks mainly include the following categories:

(1) Leakage between flanges;

(2) Pipeline leakage;

(3) Thread leakage;

(4) Valve leakage;

(5) Leakage at locations where pressure and temperature change

(6) Leaks caused by workers' operating procedures and process switching.

1.3 Causes of natural gas leakage

From a further theoretical analysis, the reasons that will cause the natural gas leakage in the above-mentioned areas are also reflected in:

(1) Due to the insufficient compression force of the natural gas pipeline sealing gasket, the roughness imbalance problem appears on the flange joint surface. Z eventually leads to insufficient tightness between the flange surface and the gasket, which causes natural gas leakage. This kind of leakage is often called interface leakage;

(2) In the interior of the natural gas pipeline sealing gasket, due to the existence of a certain small gap inside it, the pressure medium may pass through this area during the pipeline transmission process, and cause permeability leakage problems in the natural gas pipeline;

(3) Affected by the installation quality factors, the sealing gasket may have over-compression or insufficient specific pressure, which will also cause the natural gas pipeline to show different degrees of leakage.

2. Analysis and treatment measures of common leakage

2.1 Leak between Flanges

2.1.1 Causes of leakage between flanges

Flange connection is the main form of natural gas pipeline and equipment connection, and its leakage is also one of the most important forms of natural gas station leakage. Flange sealing mainly relies on the pre-tightening force generated by the bolts connected to it, through the gasket to achieve sufficient working sealing pressure to prevent natural gas from leaking. For natural gas pipelines, due to the characteristics of corrosion, high pressure and vibration during the transportation process, the natural gas pipeline flange seal will fail and cause leakage. The natural gas pipeline flange is shown in Figure 2. The main reasons for the leakage of the natural gas station flange are as follows:

(1) The sealing pressure of the gasket is insufficient, the installation of the gasket is biased, the bolts are not tight, and the center lines of the two flanges are offset. This kind of leakage is mainly caused by the construction and installation quality of the operators.

(2) Due to impulse flow, unreasonable process design, inadequate damping measures or external factors causing pipeline vibration, loose bolts may also cause leakage, or leakage caused by pipeline

deformation or settlement. This is due to the external influence on the pipeline. Leakage caused by loosening caused by affecting the connection part.

(3) The extension and deformation of the bolt due to thermal expansion and contraction, and the leakage at the turn of the seasons is mainly caused by this failure.

(4) Due to the corrosion of natural gas, the long-term use of the sealing gasket will cause plastic deformation, drop in resilience and aging of gasket materials, which will also cause leakage.

Figure 2: Natural gas pipeline flange

2.1.2 How to Deal With Flange Leakage

For flange leakage, once found, appropriate measures should be taken to deal with it in time, otherwise it will cause puncture and seriously affect safety production. The main methods to deal with flange leakage are as follows:

(1) Leakage caused by pipeline scouring and oscillation mainly relies on the pressure reduction method to reduce gas scouring the pipeline, or vent and reduce the pressure at the flange to reduce its leakage.

(2) For leakage caused by the corrosion of the gasket, a new gasket can be used. This method can choose sealing gasket materials with good plasticity, elasticity, corrosion resistance, temperature and compression resistance. For example, for high-pressure pipes, metal gaskets made of spiral wound asbestos gaskets and thin metal tapes can be used.

(3) Leakage caused by elongation and deformation caused by thermal expansion and contraction of the bolts can be used to select new bolts. The new bolts must be bolts that can resist thermal expansion and contraction to reduce their leakage.

(4) For leaks caused by operator errors, please pay attention to the operating procedures of the operator. For example, the correct installation of the gasket should be in the middle of the two flanges during the installation process. The center line of the two flanges should not be offset. The installation bolts should be tight and consistent. oblique.

2.2 Valve leak

2.2.1 Causes of valve leakage

(1) The leakage of the valve is mainly for the leakage of the valve body. The leakage of the valve body is mainly caused by casting defects in the valve production process. Of course, the corrosion and erosion of natural gas will also cause valve body leakage, which often appears on the pressure reducing valve;

(2) Leakage of sealing packing is also one of the main reasons for valve leakage. Due to the different types of sealing packing, the aging, corrosion and other reasons of the sealing packing will also cause gas leakage from the sealing packing;

(3) Leakage of the grease injection nozzle is also the main reason. This situation is generally caused by the failure of the one-way valve.

Figure 3: Natural gas pipeline valve

2.2.2 How to Deal With Valve Leakage

(1) For the leakage of the valve body, impurities in the gas can be eliminated to reduce corrosion to the valve, and the pressure can be reduced or the valve material with better pressure resistance and temperature resistance can be used;

(2) The aging packing can be replaced with new packing with the same model and better material;

(3) For grease nozzle leakage, sealing grease can be added to solve the leakage.

2.3 Thread Corrosion

2.3.1 Causes of Thread Corrosion

At present, API taper pipe threads are often used in natural gas stations. Taper pipe threads include round threads and trapezoidal threads, with a design taper of 1/8. The sealing is determined by the tightness of the internal and external threads. Due to structural design, there is a certain gap between meshing threads. The leakage of the thread seal is related to the gap between the threads and the sealing material used. Large gaps or improper sealing materials will cause leakage. Pipe thread corrosion is shown in Figure 4.

Figure 4: Pipeline thread corrosion

2.3.2 Treatment Method of Thread Corrosion

Thread corrosion reduction methods should use tetrafluoroethylene tape seal or elastic seal ring structure bolt connection or welding to reduce the leakage for reasons of large gap and inappropriate sealing materials.

3. Analysis of Leak Detection Methods for Natural Gas Pipelines

With the support of technical conditions at this stage, the detection of natural gas pipeline leakage has attracted much attention from researchers from all parties, but from the perspective of practical applications, the effect is not particularly satisfactory. The main reason for Z lies in the fact that the

detection of leaks in natural gas pipelines is relatively complicated, and the natural gas pipelines have diverse media, and the detection methods cannot achieve uniformity and reliability of application.

3.1 Types of Leak Detection Methods for Natural Gas Pipelines

Summarizing the more common natural gas pipeline leak detection methods in recent years, it can be divided into the following two types according to different working principles:

(1) Hardware-based leak detection methods for natural gas pipelines, mainly including direct observation method, probe ball method, and semi-permeable detection tube method;

(2) Software-based leak detection methods for natural gas pipelines mainly include pressure point analysis method and pressure gradient method.

3.2 Analysis of Hardware-based Gas Pipeline Leak Detection Methods

The detection methods can be divided into three types: direct observation method, probe ball method, and semi-permeable detection tube method. Among them, the direct observation method refers to relying on experienced natural gas pipeline staff to carry out the inspection work of the entire pipeline, and determine whether there is a leakage problem along the natural gas pipeline by way of inspection. Although this detection method has direct effects, it cannot achieve the continuity and dynamics of detection, so it is rarely used.

The probe ball method is to use the probe ball to detect along the inside of the natural gas pipeline. In this process, the application of ultrasound and magnetic flux leakage technology to determine the dynamics of the natural gas pipeline. A lot of data will be formed during the entire detection process. Through the later processing of the data, a variety of key information including whether the natural gas pipeline is corroded and perforated can be obtained. Its advantage lies in high accuracy and easy operation, but its disadvantage is that the detection ball may block the natural gas pipeline.

The semi-permeable detection tube method refers to burying the detection tube above the natural gas pipeline, infiltrating the pipeline leakage gas that may occur into the upper vacuum tube, extracting the gas component in the vacuum tube, and detecting its type. The advantage of this detection method is that the detection tube can penetrate natural gas and oil at a high level, but it will not cause water loss at the same time, so it has a higher accuracy. However, for the area around the biogas, it may cause the problem of false alarm.

3.3 Analysis of Software-based Leak Detection Methods for Natural Gas Pipelines

Detection methods can be mainly divided into pressure point analysis method and pressure gradient method.

The pressure point analysis method mainly refers to that if the natural gas pipeline has a leakage problem, it will cause the original equilibrium pressure to change. In this process, an expansion wave that uses sound waves as the medium and propagates along the natural gas pipeline is generated. The propagation of the expansion wave will reflect the instability problems in the pressure changes at various points. The principle of applying the pressure point analysis method for leak detection is that multiple pressure detection points are set in the natural gas pipeline, and the pressure drop time difference is calculated by analyzing the difference between the pressure value and the predetermined value, and then the specific leak point is calculated. This detection method is more effective and is also applicable to large-diameter natural gas pipelines.

The pressure gradient method mainly refers to the fact that in the case of a natural gas pipeline leakage accident, the flow rate in front of the leakage point becomes larger, and the flow rate behind the leakage point becomes smaller, resulting in the pressure distribution inside the natural gas pipeline showing a broken line state. By calculating the pressure gradient of the upstream pipe section and the pressure gradient of the downstream pipe section, the specific leakage location can be determined. Under this method, the more measurement points are set, the more accurate the determined result will be.

Natural gas pipeline is one of the key configurations related to urban development and the safety of natural gas use by the general public. If the natural gas pipeline leaks and other undesirable problems occur during normal use, it will inevitably seriously threaten the safety of the pipeline itself, as well as the protection of people and property of the general public, which is worthy of attention. All in all, this article has made a brief analysis and explanation on the leakage of natural gas pipelines and related issues involved in the detection process, hoping to provide certain reference and help for the subsequent related research and practical work.

4. Conclusion

The current research on pipeline leak detection and location technology is mostly carried out on a single pipeline and large leaks, while the research on slow and small leaks is rarely applied. Looking at the statistics of leakage accidents in China, the biggest future The challenge and research goal are slow and small leaks caused by pipeline corrosion. According to the characteristics of various leak detection systems, the real-time transient model method meets this requirement, and can solve the detection and location of pipeline small leaks and leakage calculation problems. Increase the accuracy of system detection and adaptability to multiple working conditions, and at the same time further in-depth research on the technology.

References

[1] J.W. Wang, H.Y. Wang: Influence of natural gas pipeline leakage on surrounding soil temperature, Petroleum Engineering Construction, Vol. 46 (2020) No.2, p.5-8.

[2] Y. Zhang: Analysis of Infrasonic Leakage Monitoring Technology for Natural Gas Pipelines, Chemical Management, (2020) No.10, p.136-139.

[3] L.P. Fang, J.L. Liang, C.X. Mo and J.H. Jiang: Study on the Influence of Multi-point Leakage on Pressure along Natural Gas Pipeline, China Safe Production Science and Technology, Vol. 16 (2020) No.2, p.104-109.

[4] F. Li, W.H. Wang and J. Yi: Sound-pressure coupling identification method for natural gas pipeline leakage, Applied Acoustics, Vol. 39 (2020) No.3, p.402-408.

[5] L.C. Li: Leak detection and location technology for urban natural gas pipeline network, China Science and Technology Information, (2019) No.19, p.55-56.

[6] D.W. Liu: Research on Natural Gas Pipeline Leakage Monitoring Based on Distributed Optical Fiber Sensing Technology, Anhui University of Science and Technology, (2019).

[7] C.S. Chen, J. Li, Y.H. Wu and F.C. Zhai: Application of Real-time Transient Model Method in Leak Detection of Long-distance Natural Gas Pipeline, Natural Gas Technology and Economy, Vol. 13 (2019) No.3, p.58-62.

[8] F. Li, W.H. Wang and J. Yi: Negative pressure wave-sound wave coupling natural gas pipeline leak detection and location, Industrial safety and environmental protection, Vol. 45 (2019) No.2, p.32-35.

[9] F.C. Zhang: Talking about Leak Detection Technology of Long-distance Natural Gas Pipeline, Contemporary Chemical Research, Vol. 12 (2018) No.12, p.55-56.

[10] B.K. Han, X.G. Jiang, X.Y. Liu, Y. Ji and H.Q. Bao: Research on Natural Gas Pipeline Leak Detection and Location System Based on Acoustic Method, Journal of Shandong University of Science and Technology, Vol. 37 (2018) No.4, p.102-110.