Inspection and Evaluation of Natural Gas (Methane) Leakage in Transmission Pipeline System

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Abstract

The purpose of the paper is to study the features of natural gas (methane) leakage during the process of production and transmission of natural gas in the pipeline system. In the research, we have selected the best condition for natural gas leakage inspection by means of static experience under the condition of different distance，wind speed and wind direction, and have set up method for natural gas leakage inspection. At the same time, we have selected and tested the calculating mode of gas leakage amount by means of both static and dynamic experiments. The result indicates: Firstly, the calculation of the leakage amount with the folding line integration and relative curve methods can give a more accurate description of the gas leakage in pipeline system; Secondly, when the wind speed is less the 0.8m/s (including windlessness), the leakage speed rate is more accurately calculated by measuring concentration at the leeward location 1.5-2.0m away from equipment leakage point. When the wind speed is 0.8-1.3m/s, the leakage speed rate is more accurately calculated by measuring concentration at the leeward place 1.0cm from equipment leakage point. When the wind speed is higher than 1.3m/s, the leakage measurement should not be made.

The measuring technology has been adopted to inspect the natural gas (methane) leakage in the pipeline system of Southwest oil gas field branch, and the situation of gas leakage in the whole natural gas pipeline transmission system has been made clear.

(1) In different equipment inspections, the tray base of the valve is the part where most gas leakages take place. The leakage amount of its components can be illustrated in descending order as:tray base>flange>joint >grease adding hole>blind board,

respectively amount to 50.8%, 28.8%,10.7%,8.7% and 1.0% of the total leakage amount.

(2) From 1999 to 2001, 992 leakage points has been found during the inspection of gas leakage over several stations of natural gas pipeline system, taking up 1.1 % of the total measured points. It is estimated that the total gas leakage amount of Southwest Oil and Gas Field Branch is approximately around 1752.7× 10^4 m^3 and the natural gas leakage rate is 0.08%. After timely adjustments, the leakage rate between 1999 and 2001 tended to decline.

With reference to advanced international standards, we evaluate and analyze the contribution of the natural gas leakage to the methane emission in atmosphere. It is clarified that the contribution value of natural gas leakage of pipeline system to the atmosphere environment amounts only a little to the whole methane emission amount, approximately between 0.005 and 0.025% of that in our country. At the same time, we have also given evaluation to the economic losses caused by the natural gas leakage of the pipeline system of Southwest oil and gas field branch. We have proposed effective measures and suggestion to prevent natural gas from leakage though the annual leakage inspection. In conformance with these measures and suggestion, we have made maintenance and adjustments to the equipments of the stations in order to make the natural gas leakage of the pipeline system under control. By the analysis of different annual inspections, it is known that the direct economic losses caused by natural gas leakage of the system declined 6,908,000 RMB from 1999 to 2001, with outstanding economic and social profits.

The establishment of leakage inspection and evaluation technology does not only provide a technology guarantee to the reform and maintenance of pipeline networks in Sichuan province, but also get applied in the natural gas leakage inspection and evaluation in our country.

Key words: Natural gas, Methane. Leakage, Leakage inspection, Leakage detector

1 Preface

The main component of natural gas is methane, a kind of important green house gas. Its green house effect is only inferior to carbon dioxide. The concentration of methane in atmosphere gets increased more than one time during the past 100 years. In the past 20 years, it got increased at an average speed of 0.9%, which is much higher than that of carbon dioxide. According to experts' estimation, the total amount of global methane emission is $7490\times10^{8}m^{3}$, among which 70% comes from human activities such as petro and natural gas industry, coal mining, solid waste storage, sewage processing, ripe planting, ruminate livestock feeding and biological substance burning etc.,. Therefore, much attention has been made to the issue of methane emission by governments and scientists of over the world.

After natural gas is exploited from mines, it is produced into commercial gas by the process of collection and transmission, purification and distribution. During this process, there is a certain transmission difference in the system. The reason of such difference mainly includes system leakage, station emission and instrumental error etc. The natural gas leakage of pipeline system includes internal leakage, external leakage and accidental leakage. The paper is aimed to discuss various components, such as valves, flanges etc, which lead to natural gas leakage. There are many factors influencing the accurate estimate of the methane leakage amount, such as measuring location, environmental condition during inspection, calculating mode, integral method etc. Currently, each Petrol Corp. has its own natural gas measuring method and calculating mode for the estimate of leakage.

The natural gas (methane) leakage measuring and evaluating method discussed in this paper is the joint achievement made by the natural gas measuring and evaluating research group of the Southwest Oil and Gas Field Branch Co. It is worthy to be recommended to the experts and colleagues in the same field. It is significant for methane leakage measuring and evaluation in pipeline system of natural gas industry in our country.

2. Inspection and Evaluation method of Natural gas (methane) leakage

2.1 Experiences

2.1.1 Leakage Detector and Calibration

680HVM portable hydrocarbon steaming detector adopts flame ion detector to measure burnable gas, which is suitable for natural gas leakage inspection for pipeline equipments. It has the features of wide measuring range, compact structure, convenient operation and portability etc.

There are three calibration methods used by the 680HVM, which are zero gas and low concentration normal gas calibration method, zero gas and high concentration normal gas calibration method and zero gas and high and low concentration normal gas calibration method. After 680HVM instrument is calibrated by 2 points or 3 points, it can detect the concentration taking two kinds of standard gases as given sample respectively to calculate its relative error, so as to determine the calibration method of instrument. The test results with different calibration methods are shown in Table 1:

Table 1 The result of concentration measured with different calibration methods

Calibration Methods	Two Points Calibration				Three Points Calibration			
	Calibration with zero gas and normal gas of low concentration		Calibration with zero gas and normal gas of high concentration		Calibration with zero gas and normal gas of low, high concentration			
Methane normal gas concentration (mg/m3)	915.9	5,850.4	915.9	5,850.4	915.9	5,850.4	56,800.0	113,600.0
Average Value (mg/m3)	908.8	9,248.5	569.7	5,962.6	923.1	5,996.6	55,869.9	111,218.7
Relative error (%)	-0.8	58.1	-37.8	1.9	0.2	1.9	-1.6	-2.1

Note: Low concentration normal gas----915.9 mg/m^3, High concentration normal gas——5,850.4 mg/m^3.

As shown in Table 1,in the 2 points calibration method, the relative error is less for low concentration normal gas measuring, but the relative error is larger for high concentration normal gas measuring after being calibrated with zero and low concentration normal gas. While after being calibrated with zero gas and high concentration normal gas, the relative error is larger for low concentration normal gas measuring, but the relative error is less for high concentration normal gas measuring. When being calibrated with 3 points method, the relative errors are all less whatever for low concentration measuring or high concentration normal gases. Therefore, it is recommended to select 3 points calibration method for 680HVM during the whole measuring range to guarantee the accuracy of measuring concentration.

2.1.2 Calculation Mode

F.E.M.S emission leakage management software, mainly applied for calculating natural gas leakage amount, in which there are 4 kinds of calculating modes for selection: SOCMI method, leakage/non-leakage mode, delamination coefficient and correlative curve mode. Its calculation mode for mass flux is:

$$\text{Mass velocity of flow (kg/h)} = A \times (\text{concentration})^{B} + C$$

In the formula: A, B and C are fixed constants for different kind of equipment.

Correlative curve mode is an experienced equation derived from the real measured data (concentration mass velocity of flow). For special equipment, once the correlative curve is set up, A, B and C are constants, the concentration data is the only variable.

Delamination coefficient mode is another method to calculate mass velocity of flow.

Each kind of equipment will set up a mass flow velocity in a certain range of concentration.

It divides measuring concentration into three different sections: 0～1000、1000～10000、>10000×10^{-6}(V). A, B are equal to zero, C has three constant values in the three concentration measuring ranges.

Leakage/non-leakage method, it is essentially the simplification of delamination coefficient method. It divides the measuring concentration into two different ranges, taking $10000X10^{-6}$ as the dividing point, the equipments higher than 10000×10^{-6}(V) are regarded as leakage and those lower than 10000×10^{-6}(V) are regarded as non-leakage. Here, A and B are zero, C has two constant values in two concentrations of leakage and non-leakage.

The most original calculation method is the average coefficient method(i.e. SOCMI method). When it is adopted to calculate leakage amount, constants A and B are both zero, C assumes a certain value for each kind of special equipment.

2.1.3 Experiment Method

It is to measure the leakage velocity rate of equipment by means of static and dynamic experiments. At same time, when the measurement distance, wind direction and wind speed are all the same, 680HVM detector will be used to measure equipment leakage concentration. Then the measured data will be entered into F.E.M.S software to calculate leakage velocity rate according to the 4 modes mentioned above. The result will be compared with the actually measured one and the calculation mode of natural gas leakage velocity rate will be finally settled according to the relative error.

2.1.3.1 Static Experiment

Fig.1 Simulated Experiment for Methane Leakage Inspection

Figure 1 displays static experiment device. The natural gas leakage amount is collected with drainage method. Gas with certain velocity is emitted from methane steel tank and passes through a sealed bottle full filled with water to press the water into measuring device. The time required for methane emission will recorded with stopwatch while doing the measurement. The emission velocity will be calculated with the drained water amount and the time. The next step is to measure the concentration of emitted methane with 680HVM hydrocarbon stream detector under different condition. Finally, the release velocity of methane will be calculated with F.E.M.S software. The mode with the minimum difference between the leakage velocity rate calculated by the software and the actual one will be selected as the calculation mode for natural gas leakage amount.

2.1.3.2 Dynamic Experiment

According to the actual situation of gas fields in Sichuan basin, we only select those with measurement capability. We do the research with sack method to determine calculation mode by entering different concentration value into calculating methods of SOCMI, leakage/non-leakage, detamination coefficient and relative curve and compare the result with annual leakage amount obtained from the actual leakage amount. The detail methods and steps for sack experiment are illustrated as the following:

(1) Pack up the leaking point of equipment (such as valve, flange and tie-in etc), and connect the upper end with a small pipe (there should be no leakage between the sack and the joint point), and then link with flow meter (such as rotor flow meter or foam flow meter). Measure the leakage velocity at the leaking point （ml/min） and record the time with stopwatch;

(2) Take off the sack after the flux measuring and measure the concentration at the leaking point with 680HVM (the distance between the testing point and the leaking point is 1cm apart and the maximum value is preferred);

(3) Calculate the actual leakage velocity（m^3/h） of the leaking point on equipment according to the measured flux amount；

(4) Enter the measured leakage concentration (ppm) into F.E.M.S software and calculate the leakage velocity respectively according to the 4 modes mentioned above.

(5) Compare the actual leakage velocity of equipment with that in actual measurement, and calculate the relative error (%);

(6) Select the mode with minimum relative error as the calculating mode for natural gas leakage velocity.

2.1.4 Selection of Integration Method

There are two options of integration method for leakage amount calculation in F.E.M.S emission leakage management software. Each measured data on the spot is stored into the database of stipulated supervising date. While F.E.M.S software is used to calculate leakage amount, an instruction is given to generate an emission briefing. The concentration in the stipulated period is converted into release velocity. F.E.M.S software provides two methods, straight line integration method and folding integration method to calculate leakage amount that covers the whole period.

The followings will discuss the difference between these two integration methods on the base of data in Appendix A of the user manual of the F.E.M.S software, which is intended to choose a more accurate integration method to calculate natural gas leakage amount.

Apparatus measurement (Φ,10^{-6}(V))	release velocity (kg/h)	supervising date
10000	0.91	12/24/92
5000	0.45	09/15/92
2000	0.34	06/30/92
5000	0.45	03/22/92

In these two integration methods, the straight line integration method is derived from a straight line based on the higher emission velocities on two adjacent measuring dates (see to Fig. 2). Its integral result is comparatively higher; on the other hand, folding ling integration is derived from a folding line integration of emission velocity in each measuring date (see to Fig. 3), the result gives a better reflection of the actual situation of equipment leakage. Hence, the folding line integration method is adopted during calculating natural gas leaking amount.

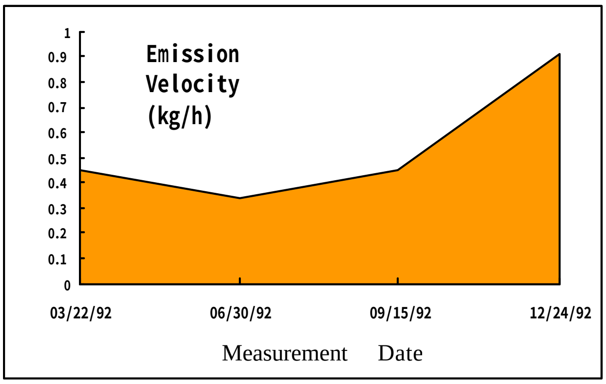


Fig.2 straight line integration leakage amount

Fig.3 folding line integration leakage amount

2.1.5 The Effect on Inspection Result by Various Factors

In order to determine the optimum condition for leakage measurement, and to offer basis for natural gas leakage inspection, static experiment is taken to investigate the effects on the measuring result by different factors. We mainly investigate the effect on measuring result by the factors of measurement distance, wind direction and wind speed. Through experiments, the optimum measurement distance, wind direction and also wind speed for 680HVM to measure equipment's leakage concentration has been determined. It also makes the leakage velocity gained by calculation mode closer to the actually measured concentration value, thereby to ensure an accurate testing data.

2.2 Experimental Result

2.2.1 Selection of the Calculation Mode

2.2.1.1 Static Experiment Result

The result of comparison between leakage rates calculated with 4 kinds of calculation modes and the actual velocity is illustrated in Table 2.

Fig.2 the Comparison of Static Experiment Results

Serial No.		1	2	3	4
680HVM measured value (mg/m^3)		3,680.3	3,592.8	476.6	469.8
Actual Measured Value in Static Experiment ($10^{-4}m^3/h$)		44.35	43.43	7.59	7.50
Relative Curve Method	Calculated Value ($10^{-4}m^3/h$)	45.37	44.35	7.62	7.54
	Relative error (%)	2.3	2.1	0.4	0.5
delamination coefficient method	calculated value ($10^{-4}m^3/h$)	23.1	23.1	1.96	1.96
	Relative error (%)	-47.9	-46.8	-74.2	-73.9
Leakage /non leakage method	calculated value ($10^{-4}m^3/h$)	1.83	1.83	1.83	1.83
	Relative error (%)	-95.9	-95.8	-75.8	-75.7

SOCMI method	calculated value ($10^{-4}m^3/h$)	83.58	83.58	83.58	83.58
	Relative error (%)	88.5	92.4	1001.2	1014.4

1014 The measured value of each serial No. is an average value among over 10 measuring results

2.2.1.2 Dynamic Experiment Result

The result of comparison between leakage amount calculated by 4 kinds of calculation modes and actual value is illustrated in Table 3.

Table 3 the Comparison of Dynamic Experiment Results

Serial No.		1	2	3
680HVM measured value (mg/m^3)		17,253.29	3,785.71	2,142.86
Actual Measured Value in Dynamic Experiment ($10^{-4}m^3/h$)		155.8	47.9	27.8
Relative Curve Method	calculated value ($10^{-4}m^3/h$)	175.4	46.73	26.45
	Relative error (%)	12.58	-2.44	-4.86
Delamination Coefficient Method	calculated value ($10^{-4}m^3/h$)	631.4	23.1	23.1
	Relative error (%)	305.3	-51.8	-16.9
Leakage /Non Leakage Method	calculated value ($10^{-4}m^3/h$)	1094.8	1.83	1.83
	Relative error (%)	602.7	-96.2	-93.4
SOCMI Method	calculated value ($10^{-4}m^3/h$)	83.58	83.58	83.58
	Relative error (%)	-46.4	74.5	200.6

The measured value of each serial No. is an average value among over 10 measuring results

From the Tables of static and dynamic experiment results, it can be found that while calculating the leakage velocity of natural gas, the relative error of relative curve method is the least among the 4 calculation modes and that of leakage/non-leakage and SOCMI method is the biggest. In other words, the leakage velocity rate is more accurate with correlative curve method. Therefore, it is more suitable to use correlative curve method during calculating leakage velocity.

2.2.2 Selection of Optimum Condition for Natural Gas Leakage Measurement

2.2.2.1 The Effect on the Measured Result by Measurement Distance

Under the condition that the wind speed is less than 0.8m/s, 680HVM is used to measure methane leakage concentration at different distance from the equipment leakage points with static experiment apparatus. Then the measured data will be entered into F.E.M.S software and the leakage velocity will be calculated using correlative curve method. The results are illustrated in Table 4.

Table 4 The Measured Leakage Result at Different Distance

Serial No.	Measured Distance (cm)	Concentration Measurement (mg/m^3)	Actual Leakage Velocity Measurement ($10^{-4}m^3/h$)	Leakage Velocity Calculation ($10^{-4}m^3/h$)	Relative Error (%)
1	1.0	8776.5	44.35	96.90	118.5
	1.5	4591.7	44.35	55.06	24.1
	2.0	3082.3	44.35	38.99	-12.1
	5.0	983.9	44.35	14.36	-67.6
	10.0	258.5	44.35	4.45	-90.0
2	1.0	1281.3	7.64	18.01	135.7
	1.5	450.4	7.64	7.30	-4.5
	2.0	267.3	7.64	4.56	-40.3
	5.0	45.1	7.64	1.03	-86.5

	10.0	18.8	7.64	0.46	-94.0

It can be drawn from Table 4 that when the wind speed is less than 0.8m/s, and at a leeward location 1.5-2.0 cm away from the measurement point, the relative error between actual measured value and calculated value is comparatively small, which means that the data measured at this distance is more accurate.

2.2.2.2 The Effect on the Measuring Result by Wind Direction

Under the condition that the wind speed is less than 0.8m/s and at a location 1.0-2.0 cm away from the measurement point, we have investigated the effect on the leakage measuring result by different wind directions. The result is illustrated in Table 5.

Table 5 the Leakage Measurement Result under Different Wind Directions

Serial No.	Wind Direction	Concentration Measurement (mg/m^3)	Actual Leakage Velocity Measurement ($10^{-4}m^3/h$)	Leakage Velocity Calculation ($10^{-4}m^3/h$)	Relative Error (%)
1	Downward	3,787.1	44.80	46.63	4.1
2	Upward	54.6	44.80	1.14	-97.5
3	90 degree	337.7	44.80	5.59	-87.5
4	45 degree down	794.0	44.80	11.86	-73.5
5	45 degree up	515.5	44.80	8.21	-81.7

It is known from the data in the table that at a fixed measuring distance, the leakage velocity calculated by measured concentration under downward wind direction is closer to the actual measured value. While under other wind directions, the difference between calculated leakage velocities and actual measured ones is quite great. Therefore, it had better to choose a leeward location at the equipment leaking point in order to guarantee the accuracy of leakage concentration measurement.

2.2.2. 3 The Effect on Leakage Amount Measurement by Different Wind Speed

Under the condition of fixed measurement distance and wind direction, methane leakage concentration is measured at different wind speed. Then the calculated gas leakage velocity will be compared with the actual measured one to determine the effect on leakage velocity measurement by wind speed. The result is illustrated in Table 6.

Table 6 the Leakage Measurement Result under Different Wind Directions and Location Distance

Serial No.	Wind Speed (m/s)	Distance (cm)	Average Value of Measured Concentration (mg/m^3)	Actual Measured Leakage Velocity ($10^{-4}m^3/h$)	Calculated Leakage Velocity ($10^{-4}m^3/h$)	Relative Error (%)
1	windless (<0.8)	1.0	1780.0	6.27	23.94	281.8
		1.5	488.8	6.27	7.75	23.6
		2.0	233.5	6.27	4.10	-34.6
		5.0	39.2	6.27	0.91	-85.5
2	0.8	1.0	408.0	6.27	6.61	5.4
		1.5	148.2	6.27	3.08	-50.9
		2.0	106.8	6.27	2.28	-63.6
		5.0	16.1	6.27	0.34	-94.6
3	1.3	1.0	2479.4	33.86	32.26	-4.7
		1.5	1201.2	33.86	17.21	-49.2
		2.0	591.6	33.86	9.23	-72.7
		5.0	157.2	33.86	2.85	-91.6
4	2.0	1.0	1508	33.86	20.86	-38.4
		1.5	775.2	33.86	11.74	-65.3
		2.0	432.4	33.86	7.07	-79.1
		5.0	104.6	33.86	2.05	-93.9

It is known from Table 6 that when the measurement distance is less than 1.0 cm, and wind speed is between 0.8m/s and 1.3m/s, the relative error between calculated leakage velocity and actual measured one is the least. When the measurement distance is between 1.5 and 2.0 cm and it is windless, the error is comparatively greater. When the wind speed is more than 1.3/s, the error is the greatest and the measurement should be stopped. When measurement distance is 5.0 cm, the error will be great at various wind speeds mentioned above.

2.2.2. 4 The Optimum Condition for Natural Gas Leakage Measurement

When wind speed is less than 0.8m/s (including windlessness), at a leeward location 1.5-2.5 cm away from equipment leakage point, the leakage velocity calculated with measured concentration is more accurate.

When wind speed is 0.8-1.3m/s, at a leeward location around 1.0 cm away from equipment leakage point, the leakage velocity calculated with measured concentration is more accurate.

When the wind speed is higher than 1.3m/s, the leakage measurement for natural gas should be stopped.

2.3 The Natural Gas (Methane) Leakage Inspection and Evaluation Method

2.3.1 The Preparation of Detectors and Measurement

Natural gas (methane) leakage detectors should be selected according to the actual situation. They should get calibrated in conformance with their requirements and then applied in measurements carried out on the spot.

2.3.2 Selection of Calculation Mode

Calculation mode for natural gas leakage amount should be determined through both static and dynamic experiments. The selection principle is to enter the measured result into 4 modes (i.e. correlative curve method, delamination coefficient, leakage/no-leakage method and SOCMI method) for calculation. Then the selection should be made according to the principle of minimum relative error between calculated leakage velocity and actual measured value. It can be drawn from experiment results that the relative error between leakage velocity and actual measured value using correlative curve method is the smallest among the 4 modes. Thus, while calculating leakage amount, it is more appropriate and accurate to select curve method to calculate leakage velocity, and then to use folding line integration method to calculate it The calculation mode is shown as following:

$$m_{in} = A \times C_{in}^{B} + K \qquad (2)$$

In the formula, A、B and K are all constants for different equipments.

(1) When the range of measured concentration Φ is between 1～100000×10^{-6}(V), K=0 and A and B are a constants. The calculation mode for leakage concentration and leakage velocity is:

Tray base (valve cover), blind board $m_{in} = 2.618 \times 10^{-6} C_{in}^{0.873} \times b_{in}$

Flange, Tie-in, Grease adding hole: $m_{in} = 4.270 \times 10^{-6} C_{in}^{0.885} \times b_{in}$

(2) When the concentration range Φ is less than 1×10^{-6}(V)时， A = 0,B = 0 and K is a constant, the calculation mode is:

Tray base (valve cover), blind board: $m_{in} = 9.184 \times 10^{-7}$

Flange, Tie-in, Grease adding hole： $m_{in} = 8.568 \times 10^{-7}$

(3). When the concentration range Φ is greater than 100000×10^{-6}(V), A=0,B=0 and K is a constant, the calculation mode is:

Tray base (valve cover), blind board： $m_{in} = 6.069 \times 10^{-2}$

Flange, joint, grease adding hole： $m_{in} = 1.136 \times 10^{-1}$

In the formual above：

m_{in}——the leakage velocity at n time(s) at i point, (m^3/h)

C_{in}——the concentration of at n time(s) at i point, (10^{-6}(V))

b_{in}——The dilution multiple at n time(s) at i point.

The determination of calculation mode for gas leakage is the crucial technology for leakage measurement. It could provide comparatively accurate data for production and management by determining the calculation mode for leakage velocity and deriving natural gas from folding line integration.

2.3.3 Evaluation Standard

At present, there is no any natural gas (methane) leakage standard in China. Hence, we have to take international standards as references. To put it in detail, the concentration of methane leakage more than 10000×10^{-6}(V) is defined as leakage.

2.3.4 Natural Gas Leakage Measuring Evaluation

The measured result of natural gas (methane) leakage is compared to settled natural gas leakage standard, in order to evaluate the equipment leakage situation at each gas station and gas pipeline of Shchuan gas fields. Prevention measures and adjustment proposals will be based on it as well. At same time, economic losses in Sichuan gas field pipeline transmission system caused by natural gas leakage will be evaluated based on the evaluation mode of economic losses.

3. The Result of Natural Gas (methane) Leakage Inspection & Evaluation

There are gas collection and transmission pipelines with total length of 110^4km and more than 700 plants and stations in Sichuan basin gas field, spreading all over districts, villages and towns in Chonqing and Sichuan province. The gas collection and transmission plants and stations are mainly equipped with apparatus rooms, various pipelines, valves, tie-ins, flanges, separators, hole boards and joint pipes etc. Among them, the valve includes brake valves, ball valves, needle valves, hole board balance valves and flat valves. Currently, these devices in plants and stations of this branch company have suffered from leakage to some extent owing to long time usage and erosion caused by sulfureted hydrogen in the natural gas.

By means of inspection and evaluation technology mentioned above, we have inspected and evaluated main gas distribution plants and stations of the gas fields with 680-model HVM gas analyzer. At the same time, the leakage volume of natural gas in pipeline transmission system and economic losses caused by it are calculated. Besides, the situation of gas leakage in different equipments, different measuring location and different measurement years are analyzed as well. Finally, the effect of natural gas (methane) to the methane emission contributions to atmosphere is discussed. All of them provide valuable basic data for natural gas (methane) leakage measurement and evaluation for pipeline transmission system.

3.1 The Selection of Natural Gas (Methane) Pipelines and Stations under Investigation

3.1.1 The Selection principle of Pipelines under Investigation

The purpose of investigation and measurement of natural gas leakage in pipeline transmission system is to clarify the distribution of natural gas leakage in the system as well as its leakage rate. Feasible proposals and measures should be made based on it, in order to prevent the leakage and pollution caused by natural gas leakage in the system. In conformance with this purpose, the selection principle of natural gas leakage inspection and investigation is stated in the following table:

Table 7 The Selection Principle of Pipelines and Stations under Investigation for Natural Gas Leakage

Serial No.	Selection Principle	Classification Result

1	Classification by the Age of Pipeline	< 10 years	10 ~ 20 years	> 20 years
2	Classification by Pipeline Diameter	< Φ350mm	Φ 350 ~ 500mm	> Φ500mm
3	Classification by Transmission Medium	Raw Gas Transmission Pipeline		Purified Gas Transmission Pipeline

3.2.2 The Result of Selection for Pipelines and Stations

In order to realize the purpose, a careful analysis is given to each pipeline and production scale and transmission capability of each plant and station. Besides, the pipeline distribution and technical information of each plant and station are collected from production sections. On the basis of all these preparations, we have chosen representative main gas collection and distribution stations as key inspection points. As a result, 12 pipelines and 72 plants and stations have been selected for inspection according to the principle mentioned above.

3.2 Leakage Inspection of Natural Gas (Methane) in Pipeline Transmission System

3.2.1 Inspection Scope

Including 72 plants' and stations' gathering and transmission processing area and natural gas measuring device area (apparatus room).

3.2.2 Classification of Measuring Points

(1) Measuring points can be classified into two categories of leaking point and non-leaking point according to the magnitude of measured concentration.

—Leakage Point: the point where the measured concentration is higher than or equal to 10000 10^{-6}(V).

—Non-leakage point: the point where the measured concentration is lower than 10000 10^{-6}(V).

(2) Measuring points can be classified into 5 categories according to the components of measuring equipment, such as flange, tray base, tie-in, grease adding hole and blind board (thereinafter as equipment).

—Flange: Flange simply connecting the ends of flange, ball valve, brake valve and hole board measuring device etc.

—Tray base: The portions of tray base of brake valve, needle valve, ball valve and release valve; valve cover and sliding board valve of hole board valve measuring device as well as balance valve.

—Tie-in: simple tie-in, joint of thermometer and pressure gauge etc.

—Grease adding hole: the portions of valve for adding sealing grease and lubricant oil.

—Blind board: The sealing board at the end of ball receiving and sending device.

3.3 The Evaluation Index of Natural Gas in Pipeline Transmission System

The leakage inspection of natural gas is complicated with abundant parameters. In order to make the evaluation more scientific, systematical and convenient, we will divide the evaluation parameters into two types: magnitude index and ratio index.

3.3.1 Magnitude Index

Magnitude index refers to the direct evaluation of the condition of natural gas leakage by taking the measuring result and data processing result as indexes, which include: checking point, leaking point and leakage amount.

(1) Checking point: includes all checking points of each gas plant and station processing area, natural gas measuring device area (apparatus room).

(2) Leaking point：Refers to the checking point of which the measured concentration is higher than 10000 10^{-6}(V) during the spot inspection.

(3) Leakage amount: converts the concentration of the check point into natural gas volume per unit time by means of FEMS software, and finally gets changed into annual leakage amount （m^3/a） .Including: leakage amount at check point, leakage amount at leakage point, leakage amount at plant and station, leakage amount from pipeline, leakage amount from gas field and total leakage amount etc.

The value of these kinds of indices is accurate and obvious. However, it cannot be used to do comparison between pipeline stations owing to the effects of the selection of pipelines and stations.

3.3.2 Rate Index

Rate index is a kind of index that do rate （%、‰）calculation with correlative parameters and amount index and the result will be used to evaluate and analyze the condition of natural gas leakage. It includes: check point leakage rate, check point leakage rate and natural gas leakage rate.

Leakage rate at checking point: rate of the leakage point of an evaluating object to its checking point (%).

Leakage rate at leakage point: rate of the leakage point of an evaluating object to its total leakage amount (%).

Leakage rate of natural gas: rate of the leakage amount of an evaluating object to its natural gas gathering and transmission volume （‰）.

The rate index is a kind of comparative index. It is more comparable and persuasive during the evaluation of natural gas leakage.

3.4 Evaluation of Natural Gas Leakage Inspection

We give evaluation to the gas leakage condition with spot measured data. Both spot measurement and data processing adopts checking point as the basic unit and then analyze the data from different equipments and checking points through gathering. Finally, a conclusive evaluation will be produced to the overall situation of natural gas leakage in pipeline transmission system of Sichuan gas field.

3.4.1 Equipment Leading Natural Gas(Methane) Leakage

The main equipment leading natural gas leakage in pipeline system includes: flange, tray base, tie-in, grease adding hole and blind board, the equipments and natural gas leakage condition are displayed as follows:

Table 8 Equipment Leading Natural Gas (Methane) Leakage

Equipment Category Evaluation index	Flange	Tray Base	Tie-in	Grease Adding Hole	Blind Board	Total

Checking Point (unit)	53157	17327	13413	9431	288	93616
Leakage Point (unit)	142	499	194	150	7	992
Leakage Rate (%)	0.3	2.9	1.4	1.6	2.4	1.1
Leakage Amount (m^3)	401082	707537	150224	121223	14144	1394210
Leakage Amount at leakage point (m^3)	225049	659788	87584	108465	13168	1094054
Leakage Rate at leakage point (%)	56	93	58	89	93	78.5

It can be found that among the 5 categories of checking points during natural gas inspection in pipeline system area:

（1） Tray base is the most unsafe equipment leading natural gas leakage. It has the most leakage points and largest amount of gas leakage. Besides, its leakage rate at checking point, leakage amount at leakage point and leakage rate at leakage point are the highest, accounting for 50%、50%、63% of each index respectively. The leakage is mainly caused by the daily operation, tray base looseness led by frequent turn-on and turn-off operation during maintenance.

（2） Grease adding hold and tie-in are the also unsafe equipment leading natural gas leakage. Though the number of leakage points and the leakage amount is less than thatof tray base and leakage point can be fixed on the spot, it is also worth drawing our attention. It is know from statistics that the leakage amount of a single leakage point of grease adding hole is rather high. For example, the leakage amount from a grease adding hole in Tiandong NO.29 valve chamber in Chongqing Gas Mine is 37980m^3/a. It is mainly because of incorrect operation and maintenance after adding grease to the hole, which leads to damages to threads.

(3) Blind board is the equipment with the least number of checking points, leakage points found and leakage amount in the 5 categories. This is because that during inspection, most of them are closed. However, it is in the second place for leakage rate. The leakage amount at leakage point accounts for 93% of its total leakage amount. The leakage is mainly caused by the internal leakage of upper valve in the blind board.

The number of checking points of flange is the biggest but the number of leakage points is comparatively small. The leakage rate at both checking points and leakage points is the lowest. The reason lies on its less operation during maintenance. Its leakage is mainly caused by installation and aging of sealing pad.

3.4.2 Checking Point and Natural Gas Leakage

The main objects of natural gas leakage inspection in pipeline transmission system are equipment such as flange and tray base etc. The leakages of different checked points between 1999-2001 are illustrated in Table 9:

Table 9 Natural Gas Leakage in Different Check Points

Checking Point Category Evaluation Index Year		Flange	Tray Base	Tie-in	Grease Adding Hole	Blind Board	Total
Checking Point (unit)	1999	10,503	4,172	3,357	2,473	81	20,586
	2000	20,309	6,367	4,843	3,485	105	35,109
	2001	22,345	6,788	5,213	3,473	102	37,921
	Total	53157	17,327	13,413	9,431	288	93,616
Leakage Point (unit)	1999	49	146	73	62	1	331
	2000	42	165	51	38	2	298

	2001	51	188	70	50	4	363
	Total	142	499	194	150	7	992
Leakage Rate (%)	1999	0.5	3.5	2.1	2.5	1.2	1.61
	2000	0.2	2.7	1.1	1.1	1.9	0.85
	2001	0.2	2.8	1.3	1.4	3.9	0.96
	Total	0.3	2.9	1.4	1.6	2.4	1.1
Leakage Amount (m^3)	1999	193,043	383,742	92,148	82,023	12,792	763,748
	2000	153,871	200,905	26,543	16,268	633	398,220
	2001	54,168	122,890	31,533	22,932	719	232,242
	Total	401,082	707,537	150,224	121,223	14,144	1,394,210

Through the analysis of measurement of natural gas leakage at different check points of plants and stations between 1999-2001, some features can be found as the following:

(1) In annual spot inspection, the number of flange inspection is always the biggest, accounting for over 50% of that of total checking points. Tray base takes the second place while blind board has the smallest number.

(2) In annual inspection, tray base has the biggest number of leakage points, accounting for 38%、58%、52% of that of total annual leakage number respectively. Tie-in and grease adding hole take the second place while blind board has the smallest.

(3) Except blind board, leakage rate of all checking points tends to decline.

(4) In annual inspection, tray base has the greatest leakage amount, accounting for 54%、47%、55% of that of the total annual leakage amount respectively. Flange, tie-in and grease adding hole take the second place. Blind board has the smallest.

3.4.3 Annual Inspection and Natural Gas Leakage

This paper discusses the inspection of natural gas leakage at selected pipelines in major plants and stations in three consecutive years since 1999. The natural gas leakages in different year are illustrated in Table 10 and Figure 4:

Table 10 Annual Statistics for Natural Gas Leakage Inspection

Year	Number of pipes	Number of Plants and Stations	Number of Checking Points	Number of Leakage Points	Leakage Rate at Checking Point (%)	Leakage Amount (m^3)	Leakage Amount at Leakage Point (m^3)	Leakage Rate at Leakage Point (%)	Leakage Rate of Natural Gas (‰)
1999	8	37	20580	331	1.61	763748	649178	85	0.08
2000	12	72	35109	298	0.86	398220	313577	79	0.04
2001	12	72	37921	363	0.96	232242	131298	57	0.03

Note: *the leakage rate of natural gas is calculated according to the natural gas transmission amount and leakage amount in different year in Sichuan gas fields.

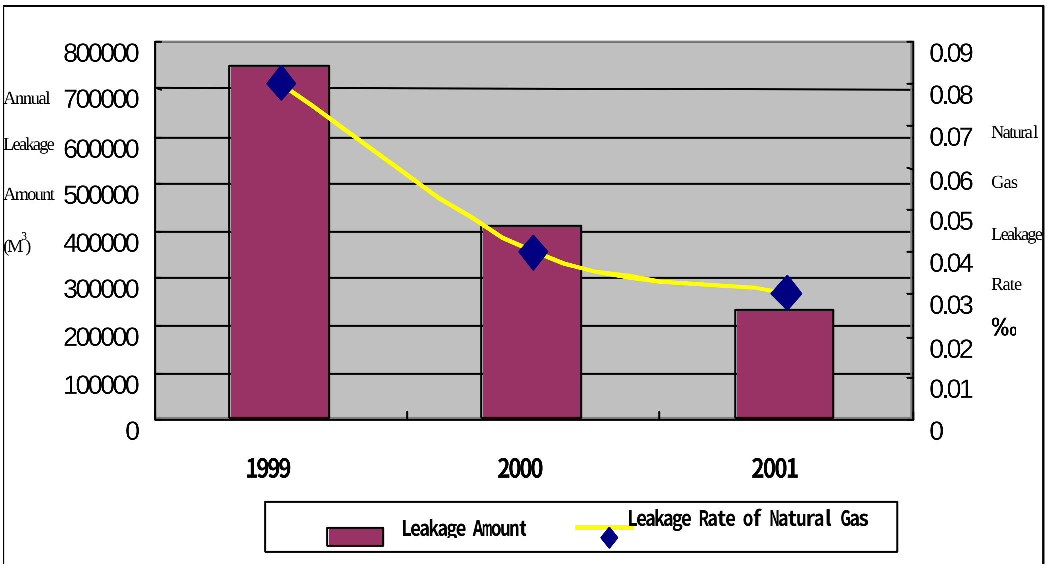


Fig. 4 Annual Distribution of Natural Gas Leakage Inspection

It can be concluded from table 11 and Fig. 4 that between 1999-2001, the number of pipeline, station and check points are increased to some extent. On the contrary, the number of leakage points, leakage rate of checking points, leakage amount and gas leakage rate are all declined annually. The number of check points in 2001 are increased 1 time more than that of 1999, but the leakage rate of check points declined from 1.61% to 0.96%. The leakage rate of natural gas declined from 0.08‰ to 0.03‰, 62.5% in reduction.

3.5 Economic Losses Analysis of Natural Gas (Methane) Leakage

3.5.1 Calculation Mode of Economic Losses

The leakage of natural gas does not only cause environmental pollution but also make enterprises suffer direct economic losses. The calculation mode is as the following:

$$I = M \times J \times 10^{-4} \qquad (9)$$

I —— Direct economic losses caused by natural gas leakage, 10 thousand RMB/a;

M —— Natural gas leakage amount, m^3/a;

J —— Average sale price of natural gas, RMB/m^3.

3.5.2 The Total Amount of Economic Losses Caused by Natural Gas Leakage and its Analysis

The direct economic losses caused by natural gas leakage are calculated according to annual natural gas leakage amount in pipeline transmission system. The losses in pipeline transmission system of Southwest oil and gas field branch company between 1999-2001 are summarized as the following table:

Table 11 Direct Economic Losses Caused by Natural Gas Leakage in Pipeline Transmission System

Year Leakage Amount and Economic Losses	1999	2000	2001	Total
Leakage Amount（m^3/a）	763,748	398,220	232,242	1,394,210
Direct Economic Losses（元）	557,517	290,699	169,536	1,017,752

From the table above, the direct economic losses caused by natural gas leakage in pipeline transmission system in 1999 was 557.5 thousand RMB, 290.7 thousand RMB in 2000 and 169.5 thousand RMB in 2001. There is a 388 thousand RMB decline from 1999 to 2001. The main reason is that some remedies and suggestions have been made after annual leakage inspections, which are helpful to maintenance and adjustment in the plants and stations.

4 Contribution of natural gas leakage to methane discharge into atmosphere

4.1 Situation of methane discharge in our country

The methane discharge is divided into non-industrial source and industrial source, non-industrial source mainly comes from paddy field, livestock and urban garbage land filling and rural compost etc, industrial source mainly comes from the release from oil gas trade, biological substance burning, mining and activities after mining.

Methane discharge of non- industrial source mainly comes from paddy field and livestock, animal soil and urban garbage take second place, the methane discharge coming form rural compost is little. The methane discharge of industrial source mainly comes from mining and activities after mining; the methane discharge coming from biological substance burning and oil gas trade is relatively small. The estimation of methane discharge in our country in 1994 is shown in Table 12.

Table 12 The estimation of methane discharge amount in 1994[1]

Serial No.	Discharge source		$10^8 m^3/a$ Methane discharge amount	Proportion	Remarks
1	Non-industrial source	paddy field	142.94	31.02	
2		livestock,	95.20	20.66	
3		Animal soil	20.86	4.53	
4		Urban garbage	15.82	3.43	
5			0.28	0.06	
6		Total amount	275.10	59.71	
7	Industrial source	Mining and activities after mining, the methane	144.48	31.36	
8		Biological substance burning	39.76	8.63	
9		Oil gas trade	1.40*	0.30	
10		Total amount	185.64	40.29	
11	Total sum		460.74	100	

Methane discharge amount in natural gas system is $0.672\times10^8 m^3/a$.

It is know form the Table that in our country, methane discharge mainly comes from non-industrial sources such as paddy field, livestock and industrial sources such as mining and activities after mining, accounting for 31.02%、20.66% and 31.36% of the total methane discharge amount respectively; and that methane discharge from oil gas trade only accounts for 0.3% of the total methane discharge amount, this means the methane discharge from oil gas trade is relatively small and has a little effect to atmospheric environment.

4.2 The contribution of natural gas leakage of pipeline system to methane discharge

Natural gas leakage of Sichuan gas field in past years is listed in Table 13, based on the statistics of its natural gas leakage of the pipeline system in Sichuan gas field.

Table 13 Natural gas leakage of pipeline system in Sichuan gas field in past years

Serial No.	Investigation year	m^3/a Leakage amount	Natural gas leakage (‰)	Ratio taking up the methane discharge amount of industrial source in our country (‰)	ratio taking up total methane discharge in our country (‰)
1	1999	763748.0	0.08	11.4	0.0165
2	2000	398220.0	0.04	5.93	0.0086
3	2001	232242.0	0.03	3.46	0.0050

Note: Ratio is calculated based on the methane discharge amount （$0.672\times10^8 m^3/a$） in natural gas system of oil gas trade in the methane discharge amount of our country in 1994.

The ratio in total methane charge amount is calculated based on the total methane discharge amount（$460.74\times10^8 m^3/a$） in our country in 1994.

It is known form this that the natural gas leakage through the pipeline system in Shichuan gas field accounts for 3.46～11.4‰ of the methane discharge amount of natural gas system in the oil gas trade in our country; accounts for 0.0050～0.0165‰ of the total methane discharge amount in out country, therefore the contribution value of natural gas (methane) leakage in pipeline system to the methane discharge in atmosphere is rather small.

5 The measures and policies for preventing from natural gas (methane) of pipeline system

This text is aiming at inspecting and investigating the natural gas leakage in major pipeline systems and some field stations of Northwest oil gas field branch, investigates and analyzes the rectifying measures taken in operation, puts forward the measures and policies for preventing from natural gas leakage in pipeline systems.

5.1 Investigation of cause of natural gas (methane) leakage

5.1.1 The cause of natural gas in pipeline

5.1.1.1 Pipeline protection invalidation, serious rust to cause perforation and leakage.

The construction periods of different natural gas pipeline systems in Sichuan experienced a comparatively long span, some had been built in 60s and 70s, some have been just newly built in recent years. Therefore, the inner and outer corrasion of the pipelines has been aggravating gradually as time passing by, the wall thickness of some pipelines are reduced 3～4mm owing to the inner and outer corrasion of pipelines. Usually the gas transmission can only be done under a lower pressure, the increased pressure in the pipelines would cause perforation and gas leakage at nights or in case of the volume of gas usage decreasing abruptly. The main reasons led to pipelines corrasion are:

(1) The geographical lands through which the pipelines traverse are more complicated, with greater difference burying depth between pipelines, the causticity of soil exits certain discrepancy, plus the inferior antisepsis layer construction in some sections.

During a long period of application, outer antisepsis layer and pipeline suffered from natural aging and artificial damage, causing some hidden troubles to threaten safe operation of pipeline. For example, in 1999, the Dong Shi pipeline occurred 23 perforations owing to corrasion, in which 21 perforations happened in farmland, 19 perforations were caused by
outer corrasion.

(2) The invalidity of cathode protection system of pipeline is also the main cause of serious corrasion of pipeline, the cathode protection system of some important pipelines such as Pa Yu pipeline, Dong Shi pipeline, and partial Wo Yu pipeline, Xia Yu pipeline

have been invalid owing to various objective reasons, which accelerated the corrasion of pipelines.

(3)The functions of separators of some stations, well mouth are not perfect, and the procedures of drainage discharging are incorrect, causing water to penetrate into pipeline, the water is accumulated at the low lying place, if the pipeline traverses river, water blocking and corrasion often occur. So corrasion and perforation often happen in this low lying places.

5.1.1.2 Landslide causes pipeline broken and explosion to lead natural gas leakage.

Some pipelines and stations are located at the places of landslide, the changes of landform and physiognomy for many years make pipelines suffer from deformations and pressures. According to the investigation, the locations suffering serious landslide are Xue Tang Pu section of Xiang Liang line, Zhu Tan and Xia Ba sections of Dong Shi line, East No.7 station, San Jiang station. In addition, the locations from Xing Long station to Xiang 12 Well Yu He village are also the places of landslide. According to statistics, from 1999 to now, there have been 20 pipelines broken caused by landslides, making $50\times 10^4m^3$ of gas leakage.

5.1.1.3 Natural gas leakage caused by the damage of pipeline owing to the violation of construction operation

Some construction teams in towns do not understand the importance of gas transmission pipelines, accidents causing pipeline damage often occur owing to brutal construction, for example, in 1999, during the construction of highway in Dadukou, Wo Yu pipeline was damaged by a bulldozer to cause $14\times 10^4m^3$ of natural gas leakage, owing to the pipeline is located at urban district of Chonqing Municipality, the accident of natural gas leakage not only caused heavy economic loss but also existed a huge safety hidden problem, and moreover, its effect to the environmental circumstance should not be neglected.

5.1.2 The causes of natural gas of station

5.1.2.1 Valve leakage

The leakage is caused by loosening of tray base owing to the process of frequent switching on or off in operation.

(2) Leakage is caused by perforation of valve body.

5.1.2.2 法兰泄漏 Flange leakage

Imperfect assembly of flange, un-alignment;

(2) Damage of sealing pad

5.1.2.3 Leakage of connector

(1) Impurities on the sealing surface (2) Sealing not tight

5.1.2.4 Leakage from grease adding hole

Damage to spring ball and spring in grease adding hole.

5.2 Measures for preventing natural gas (methane) leakage

5.2.1 Measures for pipeline leakage

The following measures for presenting from natural gas leakage should be adopted according different causes:

(1) The pipeline of serious rust and those located at landslide should be replaced with now ones, and at same time, the cathode protection system should be resumed and strengthened. Strengthening the maintenance of pipeline is a major means for preventing natural gas from leakage

The thinness parts of pipeline wall should be coolly mended to increase pressure resistance force of the pipeline.

To map the locations the pipelines, resume three stakes for pipeline, publicize to construction teams to let them protect pipeline perfectly and prevent pipeline from damage accident in construction.

To carry out intelligent pipeline cleaning, inspect the corrasion of pipeline; such as wall thickness change, the location of corrasion point.

5.2.2 Measures adopted for station leakage

5.2.2. Measures adopted for station leakage

The measures adopted for station leakage are:

To strengthen the maintenance to valves, check the tray base of valve and add grease periodically to prevent valve from leakage.

(2) When a new valve is used, read operation instruction carefully, operate strictly according to regulations, avoid turning valve violently to cause damage to the sealing surface.

(3)To replace major valve in pipeline, replace old type valve with ball valve which has better quality and performance.

(4)To replace serious eroded pad of flange and steel ring, strengthen maintenance to sealing surface;

(5) When a flange being installed and repaired, screw a bolt with even force on the cross, align flanges each other to prevent sealing surface and sealing ring from damage;

(6)When a connector being installed, align its position accurately, attach the pads of right size on each connecting place.

(7)When grease being added, do not fill it excessively, screw it with care to avoid damaging the thread.

5.2.2.2Measures for rectification and effect

(1) The effects around the replacement of GEF valve

Since 1999, the Gas Transmission Section and Chongqing Gas Mine have replaced 82 GEF valves, and carried out measurement for natural gas leakage on the effects around replacement according to the requirement. By way of statistics, it is found that 73 valves appeared serious leakage before replacements, in which 9 valves were replaced because of difficult operation, being severely damaged. The natural gas leakages of 82 valves around replacements are summarized in Table 14.

Table 14 Contrast of natural gas leakage around the replacement of GEF valves

Items	Check point piece	Leaking point piece	m^3 Leakage amount	Leak leakin

	Total No.	Distribution		Total No.	Distribution		Leaking rate %	Total amount	Distribution		Tota amou
		Flange	Tray base		Flange	Tray base			Flange	Tray base	
Before replacement	328	246	82	83	5	78	25	27942	11032	16912	1805
After replacement	328	246	82	0	0	0	0	56.3	30.5	25.8	0
Total amount	656	492	164	83	5	78	25	27998	11063	16935	1805

According to technical requirements for inspection, the numbers, positions of check points for natural gas leakage around valves replacement should be corresponding each other to make data around replacements comparable.

It can be seen form the Table:

a. 73 valves appeared serious leakage before replacement, 83 leaking points altogether, in which 5 flanges, 78 tray bases, 328 check points on 82 valves did not appear leakage after replacement;

b. The leakage amount of 82 valves is 27942m^3 before replacement; this is 496 times of those valves after replacement. As to leaking points, the main leaking location is tray base, accounting for 60% of total leakage amount.

c. Over 20000 yuan of economic loss is caused by natural gas leakage before replacement, there is no leaking point, and scattered leakage decreases after replacement to lower the economic loss to the minimum.

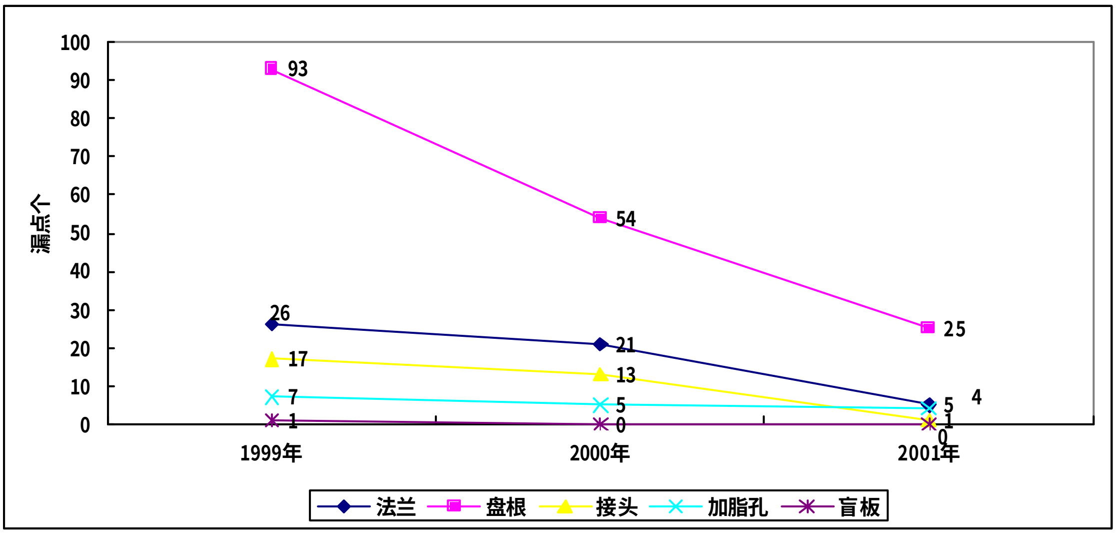
d. 17 valves are inner leakage (inner leakage will not be discussed in the text) before replacement. According to inspection result of Congqing Gas Mine in 1998, the inner leakage ordinarily some tens times even over hundred times of outer leakage.

(2) Effect of rectification of gas station

The contrast of rectification of station means to make contrast inspection to 19 stations selected for 3 consecutive years. Take annual inspection result to guide the work of equipment management and rectification of the station. Investigate the stations consistently, analyze the changes in natural gas leakage in the process of rectification of the stations.

For the contrast inspection of natural gas, it is required to ensure the measuring serial No.and type of equipment checked identical, measuring apparatus and inspector identical, also the climates should be identical approximately. 12385 groups effective contrast data have been achieved in 3 years, including 37155 check points. The leaking points measured in 1999,2000 and 2001 are 144, 93, 35 respectively, equipment leakage rates are 1.2%、0.8%、0.3%, natural gas leakage rates are 0.08‰、0.04‰、0.03‰.

The contrast measurements of leakage are summarized in following figures:



Flange Tray base Joint Grease adding hole Blind board

Fig. 5 Annual changes of leaking points of measuring equipment

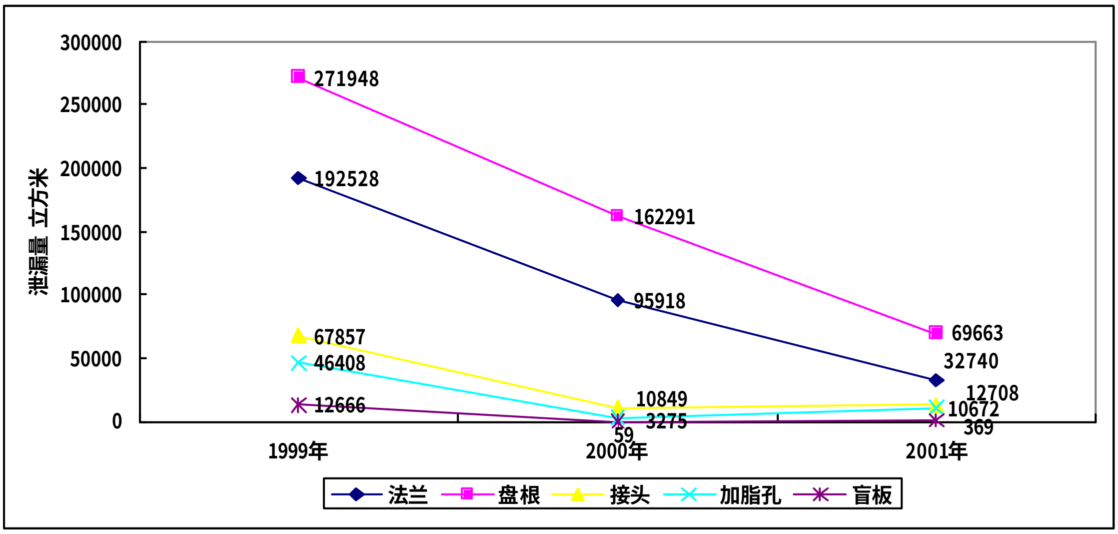


Fig. 6 Contrast changes of leaking points of measuring equipment

It can be seen from the Figures that the number of leaking points and leakage amount of 19 stations have tended to decline evidently year by year in these 3 years. The decreasing magnitude is 76%, the decreasing magnitude of leakage amount of blind board of each station is maximum, being 97%, the decreasing magnitudes of grease adding hole, tray base are minimum, reaching 77%. The leaking points are found through leakage inspection and rectify them in time, which has evident effects.

6 *Conclusion and suggestion*

6.1 Conclusion

6.1.1 Inspection and evaluation of natural gas (methane) leakage

The suitable range and application value of inspection and evaluation method

This text firstly proposes the inspection and evaluation technology on natural gas leakage of pipeline system in our country, which has the feature of easy operation, liable to master and quick measurement, it offers a complete set of inspection and evaluation method for methane leakage in natural gas transmission system. It is not only suitable for inspection and evaluation for natural gas leakage in pipeline system in our country but also suitable for inspection and evaluation for methane leakage in urban gas network. Therefore, it is valuable for popularization.

The inspection and evaluation technology on natural gas (methane) leakage of pipeline system is applied to the design of technical reform of transmission pipe system, routine management and safety appraise to make administer master the situation of leakage in stations and pipeline already built, understand leakage condition of natural gas, which is convenient for distributing funds of construction, reform and maintenance in order to change blindness, passive maintenance into foreknown construction and positive maintenance.

Selection and applicability of inspection apparatus

At present, the gas inspection apparatus incorporated with hydrogen flame detector make both in China or foreign country are all suitable for checking natural gas leakage (methane) in pipeline system as long as its

Technical specifications meet the requirements (such as measuring range and error),

The detector introduced in this text is 680HVM gas detector made in domestic maker, which have features of wide detecting range, compact structure, easy operation and portable. It is suitable for detecting leakage of burnable gas.

6.1.2 Main cause and position of natural gas (methane) leakage

Through leakage detection and evaluation, we ascertain the main reasons that cause natural gas leakage of pipeline system. The main reasons for natural gas leakage are corrasion

and perforation of pipeline, destroyed by third part, and natural disasters. The leakage of natural gas of transmission station generally occurs at places of brake valve, oil adding hole and hole board balance valve, the main reason for valve leakage mainly lies in inferior quality of valve and sealing material of bad quality, which is easy to wear out. The leakage of joint is mostly because that sealing material of inferior quality is used to form pinhole and fragileness.

To determine the main leaking parts of natural gas according to the magnitude of leaking amount i.e.: tray base >flange>joint>grease adding hole>blind board.

Tray base in valve is the most serious natural gas leaking place, where there are most leaking points with most leakage amount. We should pay more attention to this place in routine operation and maintenance management.

Joint and grease adding hole are the more serious natural gas leaking places, where the leaking points and leakage amount are less than that of tray base, the leaking points can be remedied on the spot in time, these places are also worthy to be attached importance.

6.1.3 Evaluation of measures preventing natural gas (methane) from leakage

The measures for preventing natural gas from leakage mentioned in the text have the features of easy operation, liable to management and execution. They have been applied and popularized the actual application, suitable preventing natural gas from leakage in pipeline systems in our country.

6.2 Problems existed and suggestions

The methods of detection and evaluation are not yet mature, there is no any material concerned to be used for conference. It is suggested to make these methods standardized to establish a suit of detecting and evaluating methods of natural gas (methane) leakage suitable for our country.

At present, there is no standard of evaluation of natural gas (methane) leakage in our country; there is a lack of comparison for natural gas leakage evaluation. So it is suggested to establish a standard for natural gas leakage evaluation.

It is suggested to establish administrating method of preventing natural gas (methane) of pipeline from leakage to offer a regulation for the administer department to abide by.

To strengthen the training work for the inspectors on the spot, make them master higher theory and ability for actual operation.

Each transmission pipeline station should be provided with 1-2 detecting instruments to detect and rectify ant any moment, thereby to reduce every effects caused by natural gas (methane) (such as accidents causing personnel casualties, economic loss, social and environmental effects)

The stability of apparatus is not enough; shifting phenomenon often appears on readings in the process of application. The valve leakage of steel tank is caused by frequent switching on or off of the steel tank valve of apparatus. It is suggested to perfect the functions and

performances of detecting apparatus to further enhance the stability of apparatus.

The data of detector selected in this text cannot be transmitted to data treatment software for leakage amount calculation, it is suggested to the manufactures to further improve the function of the detector to make it incorporate with intelligent management functions.

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