

# Research and Analysis on Corrosion of a Gas Gathering Station in a Gas Field in Northern Shaanxi

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## Abstract

This study focuses on the current corrosion situation of a gas gathering station in northern Shaanxi. Multiple experimental methods are used to conduct a systematic analysis and evaluation of corrosion coupons, aiming to clarify the corrosion behaviors and laws at different positions of the gas gathering station. By analyzing the main corrosion factors and combining the corrosion characteristics of the system, in-depth investigations of the corrosion details at each stage are carried out with the help of methods such as weight loss, scanning electron microscope (SEM), energy dispersive spectroscopy (EDS), X-ray diffraction (XRD), line scanning, and pitting degree. The results show that the main elemental compositions of the corrosion products on the surfaces of the coupons in the incoming pipeline, sewage pipeline, and outgoing pipeline are Fe, C, S, O, and elements such as Na, Ba, and Si are also contained. It can be seen that the distribution of deposits on the coupon surfaces is uneven, and the corrosion product films in some areas have fallen off. The main corrosion products on the coupon surfaces are  $\text{FeCO}_3$  and a small amount of  $\text{FeS}$ , and the main cause of corrosion is mainly  $\text{CO}_2$ .

## Keywords

Gas Gathering Station; Corrosion Detection; Corrosion Products; Hanging Analysis.

## 1. Introduction

In response to the corrosion problem in the gathering and transportation system of Shaanbei gas field, this article adopts the weight loss method technology. According to NACERP0775-2005 "Preparation and installation of corrosion coupons in oilfield production and analysis of test data", corrosion coupons were installed in the inlet pipeline, sewage pipeline, and outlet pipeline, and the corrosion situation was continuously monitored for 402 days. Dynamic monitoring was conducted to analyze and characterize the collected corrosion product films, corrosion products, and three-dimensional structures after corrosion in detail. The research results can provide quantitative corrosion rates and deepen the understanding of the internal mechanisms of corrosion. [1] On this basis, the corrosion characteristics of the gas gathering system in Shaanbei gas field were further analyzed. We compared the corrosion characteristics of different types of pipelines and identified the key factors that affect pipeline acceleration and corrosion reduction.[2]

The gathering pipeline contains corrosive gases such as  $\text{H}_2\text{S}$  and  $\text{CO}_2$ .  $\text{H}_2\text{S}$  will react with the metal surface to generate ferrous sulfide, and its volume expansion will lead to the rupture of the facial mask on the metal surface, accelerating the corrosion process; In the presence of water,  $\text{CO}_2$  will form carbonic acid, reducing the pH value of the medium and causing acidic corrosion.  $\text{H}_2\text{S}$  is considered the dominant factor in corrosion, while temperature and pH are the main influencing factors, and  $\text{CO}_2$ ,  $\text{Cl}^-$ , and S are promoting factors. The  $\text{Cl}^-$  content is high, and chloride ions can easily damage the surface of iron sheets, causing pitting corrosion and accelerating the corrosion process. The corrosion under scale caused by scaling cannot be

ignored, mainly composed of BaSO<sub>4</sub>, CaCO<sub>3</sub>, FeS<sub>2</sub>, FeCO<sub>3</sub>, and a small amount of other substances such as SiO<sub>2</sub>.

## 2. Corrosion Detection Technology for Gas Wells

### 2.1. Weight Loss Hanging Method

Place a metal hanging piece with known mass and surface area in a corrosive environment. After a certain period of corrosion, remove the hanging piece and clean it thoroughly.[3] Accurately weigh its mass again. By analyzing the quality changes of the hanging piece before and after corrosion, combined with factors such as the surface area and corrosion time of the hanging piece, the corrosion rate of the metal can be calculated using the following formula:

$$V_c = \frac{8.76 \times 10^4 (m_1 - m_2)}{A \times \rho \times t} \quad (1)$$

In the formula:  $V_c$  is the average corrosion rate, mm/a;  $M_1$  is the original mass of the hanging piece, g;  $m_2$  is the hanging piece mass after acid washing, g;  $A$  is the total area of the hanging piece, cm<sup>2</sup>; For hanging density, g/cm<sup>3</sup>;  $T$  is the corrosion time, h.

### 2.2. Determination of Pitting Corrosion Rate

Place the hanging piece after removing the corrosion product film on the Olympus DSX500 optical digital microscope stage, adjust it to 3D in white balance mode, and then observe it at a magnification of 500 times. Measure the depth of multiple pitting pits and obtain the maximum pitting depth  $h_{max}$ .

$$V_d = \frac{365 \times h_{max}}{t} \quad (2)$$

In the formula:  $V_d$  is the pitting rate, mm/a;  $H_{max}$  is the maximum pitting depth, mm;  $t$  is the corrosion time, d.

### 2.3. Analysis of Corrosion Products

After the corrosion test is completed, remove the hanging piece from the pipeline. 1) Rinse with petroleum ether to dissolve the oil, grease, and other organic impurities on the surface of the hanging piece; 2) Rinse with acidic solution, which can react chemically with the corrosion products on the surface of the hanging piece and dissolve them; 3) Then rinse with anhydrous alcohol to remove moisture, achieve dehydration, and further clean; 4) Use natural air drying, be careful not to use high temperature drying to avoid oxidation and other reactions on the surface of the hanging sheet.[4] FEIQuanta600F scanning electron microscope and OXFORDINCAenergy350 spectrometer were used to perform planar scanning of the corrosion products of the sample after corrosion, and analyze their composition.

Afterwards, the corroded test piece is sealed with epoxy resin, and after the epoxy resin solidifies, it is polished step by step with 800, 1000, 1500, and 2000 grit sandpaper, and the polished surface is cleaned. Using line scanning for cross-sectional analysis of hanging pieces can quickly obtain the types and relative contents of elements in different areas of the cross-section.[5]

Take the corrosion products on the surface of the hanging piece, grind them, and analyze the composition of the corrosion products using a D/MAX-2400 X-ray diffractometer.

### 3. Analysis of Corrosion in Gas Wells

#### 3.1. Hanging Analysis

Observing the morphological characteristics of the corroded hanging piece as shown in Fig. 1, corrosion products are generated on the entire surface, causing a uniform color change on the hanging piece surface.[6] As the corrosion progresses, the roughness of the metal surface usually increases, becoming less smooth. The originally smooth metal surface may have slight unevenness, which can be felt by touching the surface with the hand.[7]

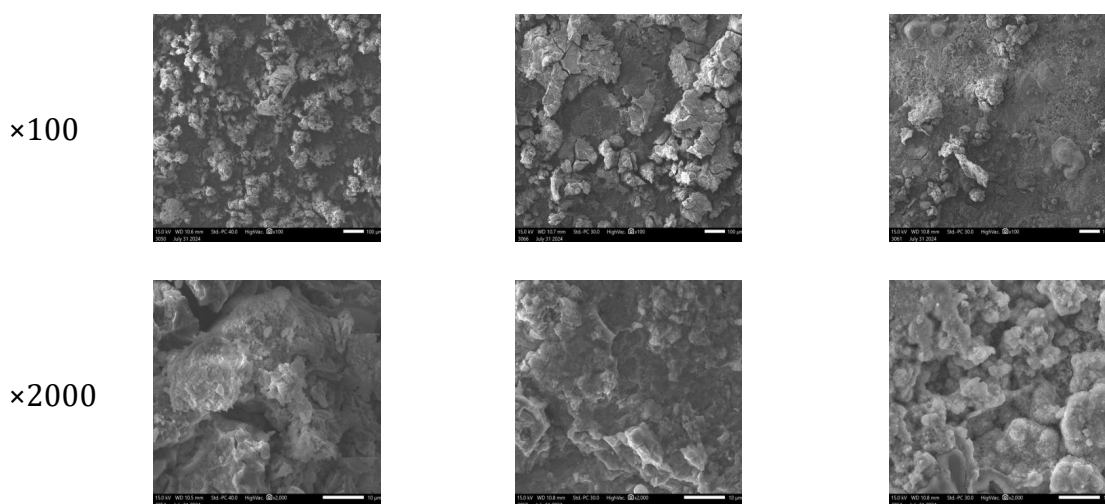


(a) Inbound pipeline (b) Sewage pipeline (c) Outbound pipeline

**Fig.1** Morphological features after hanging the sample

#### 3.2. SEM and EDS Analysis

By using SEM technology to observe the corrosion products of the gas gathering station at 100x and 2000x magnification, it was found that there were processing marks on the surface of the inlet pipeline hanging plate, indicating slight corrosion and less accumulation of corrosion products.[8] The surface of the hanging plates on the sewage and outbound pipelines is rough, with obvious accumulation of corrosion products in the form of cells or filaments, and localized corrosion pits. As shown in Fig. 2.

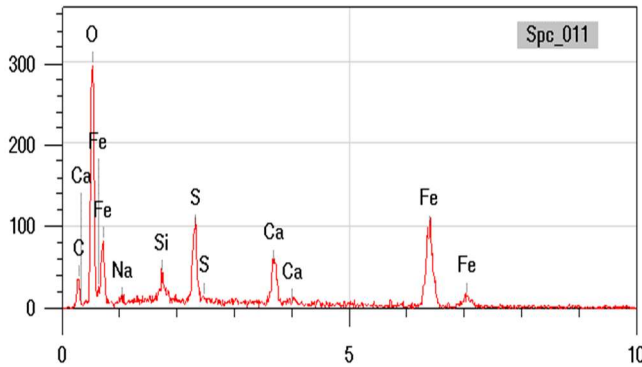


(a)Inbound pipeline (b)Sewage pipeline (c)Outbound pipeline

**Fig. 2** Observation Results of Surface Scanning Electron Microscopy on Gas Gathering Station Hanging Plates

According to Fig. 3, through EDS analysis of corrosion products, the main elemental composition on the surface of the hanging piece after corrosion is Fe, C, O, S, as well as Na, Ca, Si and other elements. [9] It can be seen that the distribution of sediment on the hanging piece

surface is uneven, and the corrosion product film has peeled off in some areas. The surface of the hanging piece is covered by corrosion products FeS and FeCO<sub>3</sub>.

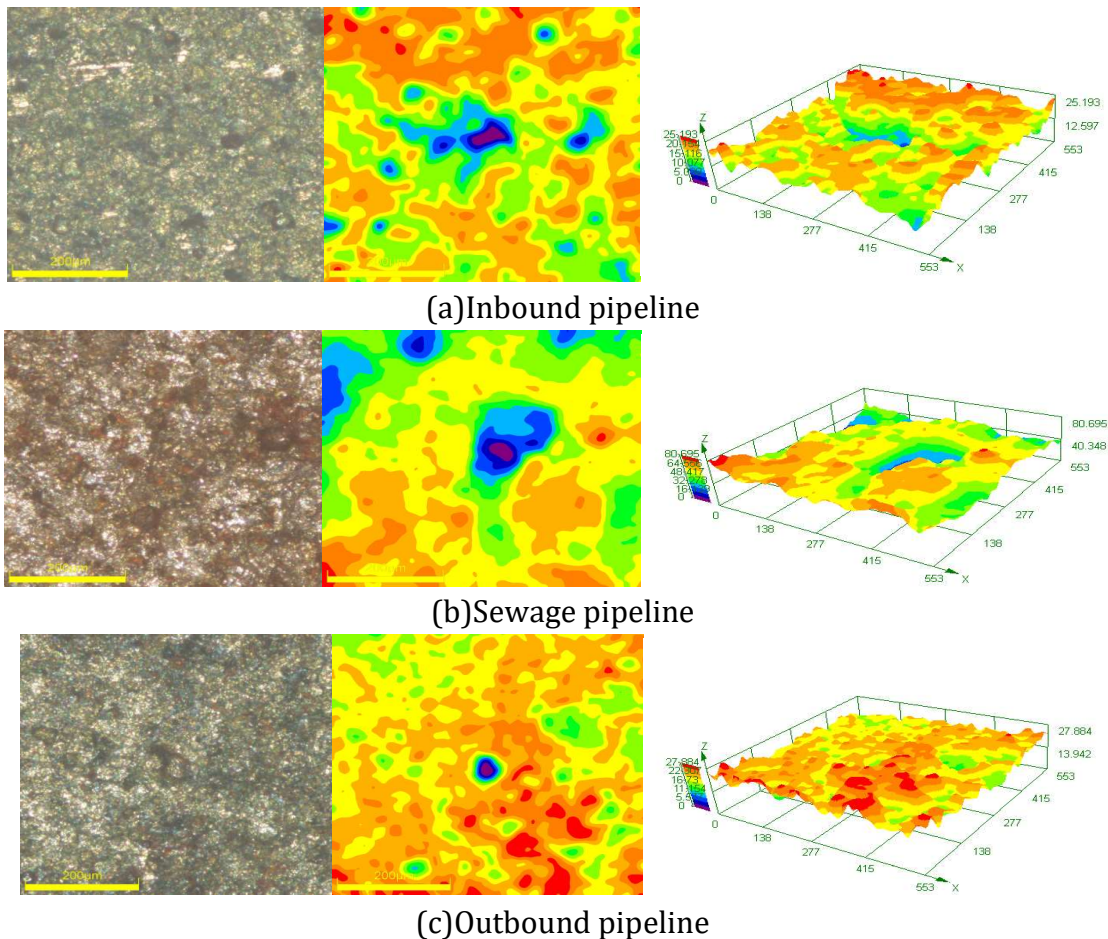


spectrogram element	spectrogram	
	weight percentage/%	atomic percentage/%
C K	6.44	13.82
O K	33.50	53.95
NaK	0.52	0.59
SiK	1.52	1.40
S K	6.66	5.35
CaK	6.65	4.28
FeK	44.69	20.62

**Fig.3** Energy dispersive spectroscopy (EDS) analysis of corrosion products

### 3.3. Analysis of Pitting Depth

Three different locations with severe pitting corrosion on the surface of the hanging plate after acid washing at the gas gathering station were scanned for three-dimensional morphology, in order to obtain the corrosion depth of the hanging plate surface and calculate the maximum pitting depth. Refer to Fig. 4.



**Fig.4** Maximum pitting depth of gas gathering station

### 3.4. Corrosion Rate Analysis

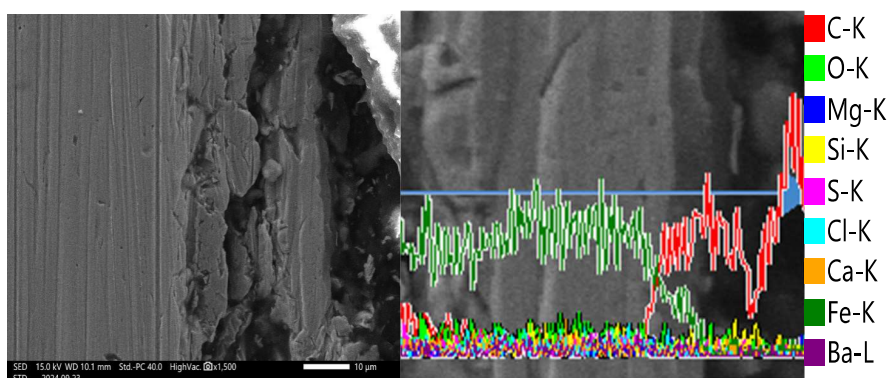
The corrosion rate measurement results of hanging pieces at the entrance, sewage station, and exit are shown in Table 1 below.[10]

**Table 1.** Results of Corrosion Rate Measurement for Hanging Plates

Sampling location	Uniform corrosion rate/ mm·a <sup>-1</sup>	Maximum pitting depth/ h/μm	Pitting rate/(m m·a <sup>-1</sup> )	corrosion degree
Station entrance	0.0119	28.411	0.0258	mild
At the sewage tank	0.0025	84.401	0.0766	mild
Exit location	0.0056	27.884	0.0253	mild

### 3.5. Analysis of Element Distribution in Section

Firstly, the corrosion coupon is encapsulated using epoxy resin. After the coupon is completely solidified, it is removed and its surface is polished with sandpaper of different roughness.[11] Finally, the surface is scanned and analyzed using a scanning electron microscope, as shown in Fig. 5.

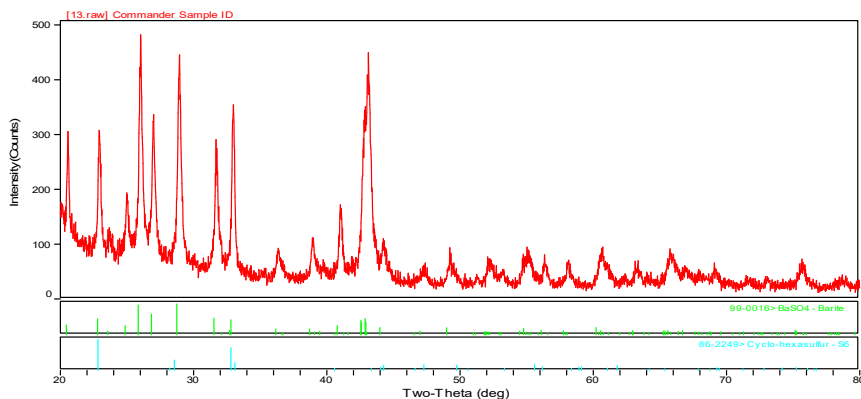


**Fig.5** Cross section analysis results of gas gathering station

From Fig. 5, it can be seen that the thickness of the corrosion product film at the inlet, sewage tank, and outlet of the gas gathering station is in the order of inlet>sewage tank>outlet. Overall, the Cl element is almost uniformly distributed on the cross-section of the hanging plate, while the C and O element content fluctuates greatly and accumulates near the substrate. This indicates that the corrosion of the gas gathering station is mainly caused by CO<sub>2</sub>, and the corrosion product is FeCO<sub>3</sub>. Under certain conditions, it may decompose and release carbon dioxide, causing changes in the acidity and alkalinity of the local environment and accelerating the corrosion process of metals.

### 3.6. XRD Analysis of Corrosion and Scaling Products

Scrape off a small amount of adhesion on the surface of corroded hanging pieces at the entrance of the gas gathering station (there is too little residue on the surface of hanging pieces at the sewage tank and exit, and the collection amount cannot meet the minimum XRD testing requirements, making it impossible to test XRD), and use the D/MAX-2400 X-ray diffractometer produced by Nippon Science Corporation for analysis.[12] The results are shown in Fig 6.



**Fig.6** XRD Results of Gas Gathering Station Hanging Plates

As shown in Fig. 6, the main component of the attached material on the surface of the hanging plate at the entrance of the gas gathering station is BaSO<sub>4</sub>, which is consistent with the energy spectrum results. The barium sulfate scale layer covering the surface of the hanging plate can mask the corrosion of the metal itself, making it difficult to directly observe the degree of corrosion of the hanging plate, such as the depth and distribution of pitting pits, the uniform corrosion rate, etc. Chemical reagents are used to dissolve it.

#### 4. Summary

(1) There are processing marks on the hanging surfaces of the inlet pipeline, sewage pipeline, and outlet pipeline of a gas gathering station in northern Shaanxi, and the degree of corrosion is mild; There are varying degrees of corrosion defects on the surface of the hanging plates of three different pipelines, all of which form pitting corrosion, and the sewage pipeline has severe pitting corrosion.

(2) The hanging pieces of the inlet pipeline, sewage pipeline, and outlet pipeline of a gas gathering station in northern Shaanxi have a high content of S element, and there is scaling phenomenon in the inlet pipeline. The main product composition is BaSO<sub>4</sub>.

(3) Due to the significant fluctuations in the distribution of C and O elements, they are enriched near the substrate, indicating uneven distribution of sediment on the surface of the hanging plate, and detachment of corrosion product films in some areas. Based on the cross-sectional analysis of corrosion products, it can be concluded that the corrosion products on the surface of the hanging plate are mainly FeCO<sub>3</sub> and a small amount of FeS, and the main cause of corrosion is CO<sub>2</sub>.

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