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Failure analysis of a natural gas pipeline

Yafan Zhao [a,*], Mingda Song [b]

[a] Shandong Jianzhu University, Jinan 250014, PR China
[b] Shandong Special Equipment Inspection Institute, Jinan 250013, PR China

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ABSTRACT

A L390 natural gas pipeline exploded in 2011 in China. Macrofracture examination, thickness measurement, chemical composition analysis, metallographic inspection, mechanical property testing, fracture scan electronic microscopy examination and environment analysis were conducted to the burst pipeline. The results showed that Stress Corrosion Cracking (SCC) generated in the mechanical damaged zone of the pipeline was the reason of the failure. This kind of cracking was induced by Cl^- and HCO_3^- in near neutral corrosive medium of pH value. The stress concentration was induced by the groove damage under inner pressure.

1. Introduction

Natural gas pipelines need a high level of reliability and safety. Failure analysis of the fracture cases can provide a warning to the in-service pipeline. Failure cases involving of natural gas pipeline are not rare [1–3]. Both the experiment and simulation approaches were used for the failure reason detections [4–6]. Some life prediction [7] and integrity assessment [8] works were conducted for the pipeline steel to prevent the abnormal failures during service. In this paper, a failure case of a natural pipeline burst was introduced. The accident happened on July 2nd in 2011, which damaged about 100 m^2 forest and lead to a villager's severe burnt, as shown in Fig. 1.

The failed natural gas pipeline was constructed on November 1st in 2001 and came into service in 2002. The pipeline had been in service for about 10 years without any periodical inspection before the accident. The material of the pipeline is L390, and the specification is φ508 × 7.9 mm. The design pressure is 6.4 MPa, and its actual operating pressure is 4.46 MPa before the accident.

The accident site is located at about 50 m south of Yellow River Second Dam and about 100 m north of Jinan–Qingdao expressway, as shown in Fig. 2. The explosion point of the pipeline was located on the shore of a sewage ditch, as shown in Fig. 3. About 50 m east of accident spot, about 5 m of the casing pipeline was immersed in the sewage witch, as shown in Fig. 4.

2. Failure analysis

2.1. Macroappearance of the fracture surface

The pipeline cracked along axial direction, and the blasting zone was flat basically, as shown in Fig. 5. Most of the fracture surface was covered by oxide film, which indicates that the pipe was burnt in the fire, as shown in Fig. 6. Severe mechanical scratches were found on the outer surface axially along the rupture zone. The mechanical scratched zone was about 1300 mm

* Corresponding author.
E-mail addresses: zyf_prc@163.com, zhaoyfsmd@163.com (Y. Zhao).

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Fig. 1. Field of fire.

Fig. 2. The fired trees around fracture pipeline.

Fig. 3. The sewage ditch in the south side.