Engineering Failure Analysis 18 (2011) 963–970

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Failure analysis of stress corrosion cracking occurred in a gas transmission steel pipeline

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ARTICLE INFO

Article history:
Received 10 August 2010
Received in revised form 30 October 2010
Accepted 28 November 2010
Available online 7 December 2010

Keywords:
API 5L X60
Stress corrosion cracking
Pipeline
Intergranular

ABSTRACT

In January 2010, stress corrosion cracking was occurred in a high-pressure gas pipeline steel in northern regions of Iran, after almost 40 years since its installation. In this study, failure mechanisms were determined based on available documents and metallographic studies conducted on this pipeline. The results showed that the applied polyethylene tape coating on the external surface of the pipeline became opened and disbonded in the corroded area causing external surface of buried pipeline to be exposed to wet soil around it. As a result of the chemical interactions and formation of carbonate/bicarbonate solution and with the presence of tensile stresses, stress corrosion cracking occurred in the longitudinal direction and at the outer surface of the pipe. In addition, mechanisms and morphology of cracks propagation due to stress corrosion cracking to internal side of the pipe wall were studied.

1. Introduction

Stress corrosion cracking in oil and gas transmission pipelines used in oil and gas industries is a highly important issue, because always the leakage or rupture and failure of the pipelines can pose a potential threat to humans and environment. As a result, corrosion and defects detection of pipelines is essential [1].

Generally, buried pipelines in soil with more than 5 years of life, experience different types of corrosion and metallurgical defects' especially cracks. The source of these cracks can be defects that randomly exist and come to existence due to construction or demolition processes of carbon steel pipeline. Combination of stress (such as Hoop stress or residual stress) with natural soil environment which contains different amounts of moisture and oxygen, promote the initiation of cracking and accelerates its growth in the thickness of the pipe.

In the pipeline during operation, the cracks can grow from primary sizes to critical sizes leading to leakage (especially in the pipelines with small wall thickness) or a sudden failure (particularly in the pipelines with large wall thickness). Stress corrosion cracking on the external surface of pipeline steel has occurred in many countries (such as Australia, Iran, the United States, Canada, and Pakistan), it has been followed by catastrophic events [2,3].

In this case study, the causes of stress corrosion cracking of API 5L X60 steel gas pipeline that was installed in the northern regions of Iran, has been studied. Chemical analysis of alloy steel pipeline above in comparison with the standard API SPEC 5L Grade X60 is given in Table 1 [4]. The mechanical properties of the steel discussed in this article using an Instron servo hydraulic machine evaluated by tensile tests and the results are listed in Table 2. Tensile and yield strengths values are located in the range of standard API 5L X60. Macro hardness tests were performed to clarify the hardness of base metal on three points to achieve reproducibility. The hardness Vickers tests results are shown in Table 3.

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doi:10.1016/j.engfailanal.2010.11.014