RESEARCH ARTICLE | OCTOBER 13 2022

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AIP Conf. Proc. 2503, 050077 (2022)
https://doi.org/10.1063/5.0099908

Recommendations for the Repair of Gas Pipeline Sections Containing SCC Defects Up to 10% of the Pipe Wall Depth

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Abstract. The SCC problem remains discussed until now, despite 40 years of research. The approaches to SCC of scientific organizations to defects up to 10% deep are considered. The mechanism of development depending on soil pH is described. Measures are proposed taking into account the acidity of the soil.

INTRODUCTION

Stress corrosion cracking defects “Fig. 1” (SCC) are the most dangerous of all types of corrosion damage to gas pipelines, most often leading to accidents“ Fig. 2 ”on the linear part (LP) [1]. Such accidents cause significant damage not only to the environment, but also to the Russian economy.

From the statistics obtained in the analysis of accidents in main pipelines at PJSC Gazprom over the past 20 years, it follows that SCC was the cause of at least 50% of accidents. Therefore, in the course of technical diagnostics of the LP sections of main gas pipelines (MG), the greatest attention is paid to SCC defects. However, statistics show that despite the significant volume of annual repair work (including the re-insulation of sections of the main section of the main gas pipeline), the number of such defects does not decrease [2].

These facts give reason to believe that the methods used to reduce defect formation are not fully effective, since all the features of the nucleation and development of SCC defects are not taken into account. One of the confirmation of the above can be the results of the analysis of data obtained in 2016 by the staff of the "Expertise" Company (Yekaterinburg) during the investigation of accidents. According to these data, approximately 25% of the total number of accidents occurs within 2 years after the major overhaul of the main gas pipeline sections.

International Conference on Modern Trends in Manufacturing Technologies and Equipment 2021
AIP Conf. Proc. 2503, 050077-1–050077-5; https://doi.org/10.1063/5.0099908
Published by AIP Publishing. 978-0-7354-4221-4/$30.00

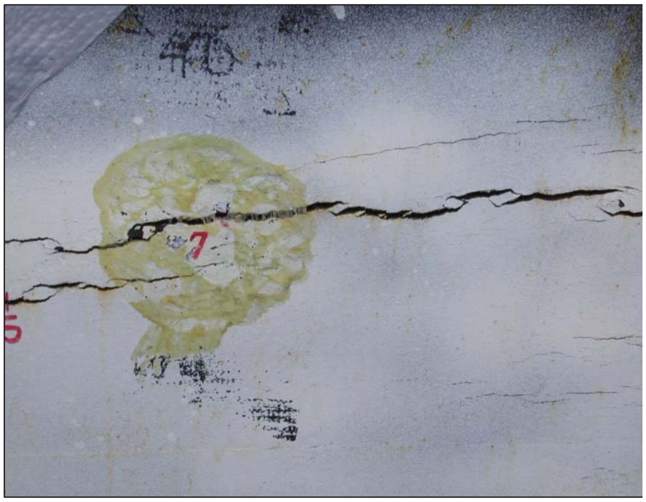


FIGURE 1. SCC defect

FIGURE 2. Accident due to SCC

APPROACHES TO ASSESSING THE DEGREE OF HAZARD SCC

Let's consider the main of the existing approaches to combating SCC, including those described in the current regulatory documentation.

In 2013, Gazprom adopted a regulatory document on the assessment of defects in pipes and fittings (hereinafter referred to as the “Instruction”), which prescribed “upon detection of stress-corrosion defects in pipes and SDTs, they should be additionally examined in the amount of 100% of the surface area in basic or factory conditions. " At the same time, "repair of pipes and SDTs with stress-corrosion defects, as well as cracks of any origin, during major repairs in route conditions is not allowed. Pipes and SDTs with the indicated defects must be repaired only under factory or basic conditions."

At the first consideration, the approach, which prescribes for enterprises operating main gas pipelines, 100% cutting of pipes with crack-like defects, solves the problem of eliminating the revealed defects of the SCC, but in practice, the provisions of the Instruction significantly complicate the process of overhaul of the main pipelines' sections as a whole, since they involve significant costs for the transportation of pipes, an increase in the time of repairs, and also do not provide for the current workload of pipe plants.

Subsequently, several subsidiaries of PJSC Gazprom introduced the practice of using mini-plants for the repair and rejection of used pipes, but this only helps to partially meet the need for repairs of main gas pipelines in accordance with the requirements of regulatory documents.

It follows from the above that the provisions of the Instruction are not fully adapted for use in production, since the approaches to repairing pipes with crack-like defects described in the document cannot be fully implemented in practice.

Taking into account that the Instruction is a valid normative document, mandatory for use in subsidiaries of PJSC Gazprom and, at the same time, taking into account the obvious need to revise approaches to the process of repairing pipes with crack-like defects, specialized research institutes, including LLC «Gazprom VNIIGAZ», carry out experimental work in order to optimize the cost of repairs.

Research results show that approaches to repairing SCC defects can be different. According to the employees of Gazprom VNIIGAZ LLC, defects of the SCC, up to 10% of the pipe wall thickness, are not dangerous and can be equated with defect-free pipes [3].

These conclusions were made after, within the framework of hydrocyclic bench tests, a section of a pipe with SCC defects up to 10% of the pipe wall thickness was loaded with 10,000 cycles, which, according to the authors, is equivalent to 100 years of gas pipeline operation. At the same time, SCC defects did not grow. The authors also make the assumption that since SCC defects with a depth of up to 10%, according to the test results, did not begin to develop, then a pipe with such defects can be compared with a defect-free pipe and left in operation. In continuation of the research, the authors propose to finally solve the problem with the possibility of developing these defects by preserving them, including using protective coatings with inhibiting compositions [4] and [5], excluding access to the surface of pipes of a corrosive medium.

Such considerations are not new. At different times, various research organizations have put forward similar statements. For example, the basic document "Stress corrosion cracking" [6] describes a methodology based on data on the development of SCC defects, collected by the non-profit organization Canadian Energy Pipeline Association. The methodology states that SCC defects less than 10% of the pipe wall thickness are not dangerous, since they practically cannot collapse under the influence of fatigue loads in gas pipelines. Their removal by grinding does not lead to an increase in the mechanical strength of the pipe (the best option is sandblasting and restoration of the integrity of the protective coating with the termination of electrolyte access to the base metal of the pipe) “Fig. 3 ”.

Thus, both of these organizations offer, in general, a unified approach in relation to operating organizations to the repair of SCC defects with a depth of up to 10% of the pipe wall thickness - limiting access to the surface of the pipes of the soil electrolyte.

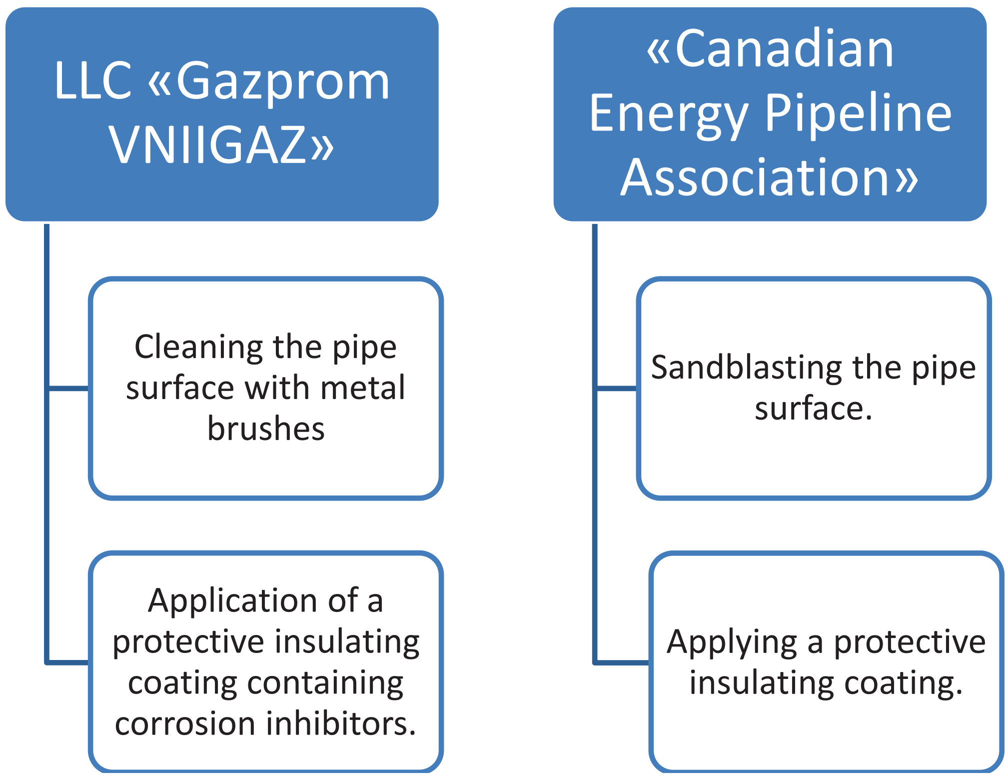


FIGURE 3. The proposed method for repairing SCC defects with a depth of 10% of the pipe wall thickness

SPECIAL OPINION

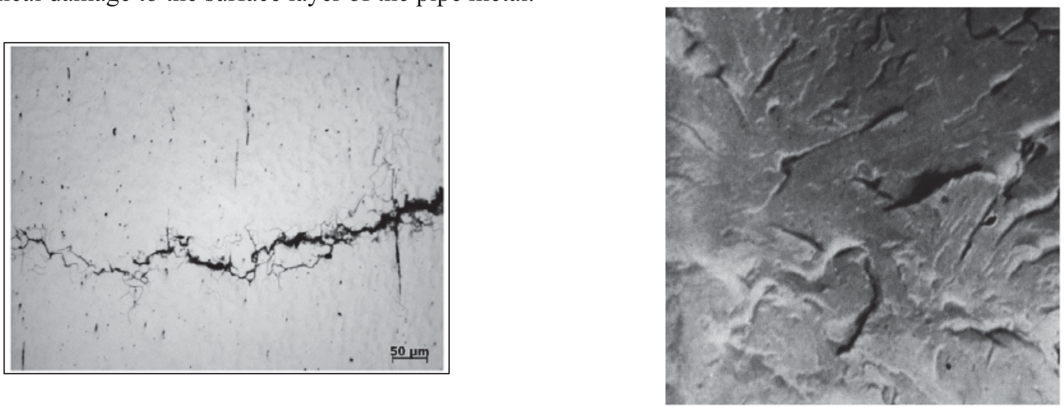
The difference is that the studies of LLC «Gazprom VNIIGAZ» did not take into account that SCC defects do not have a single cause of origin and development. Previous studies have proven [7 - 10] that SCC defects by the mechanism of origin and development are subdivided into 2 groups “Fig. 4".:

1. Formed at high pH (> 9) soils.
2. Formed in almost neutral media (pH 5 ÷ 7.5).

Basically, cases of SCC defects detection at high pH (> 9) were recorded when determining the causes of the destruction of gas pipelines in the United States. At the same time, the mechanism of destruction of the pipe metal is intergranular.

In almost neutral media (pH 5–7.5) SCC is formed through transcrystalline crack propagation, that is, when the crack propagates along the grain body, and not along the grain boundaries [11].

This type of SCC formation was mainly recorded during the investigation of cases of destruction of gas pipelines in Russia and Canada [12]. Electrolytes in such soils contain surfactants, which, when absorbed on the surface of the pipe metal, lead to a local decrease in the strength of the steel (embrittlement). Such defects arise not for corrosive reasons (combination of corrosion defects: pitting ulcers, etc.), the concentrators are risks, sunsets and other mechanical damage to the surface layer of the pipe metal.



(a) (b)

FIGURE 4. Types of SCC defects according to the mechanism of nucleation and development
a, – view of the Intergranular corrosion; b – transcrystalline fracture

CONCLUSIONS

Thus, when determining the method of repairing pipes with SCC defects with a depth of less than 10% of the pipe wall thickness formed by the principle of transcrystalline propagation, it is not enough to restrict the access to the pipe surface of the soil electrolyte.

Before applying a protective insulating coating, it is advisable to take measures to determine the pH of the soils in which the defective area lies and to adopt the mechanism of cracking in accordance with the pH value:

1.pH 5 ÷ 7.5: the mechanism of cracking is transcrystalline. The list of technical measures for the repair of the defective area should include sandblasting of the metal surface followed by the application of a protective insulating coating.

2. pH> 9: intergranular crack formation mechanism. When repairing a defective area, limit yourself to applying a protective insulating coating.

ACKNOWLEDGMENTS

The work was performed within the state assignment on the subjects Diagnostics (No. AAAA-A18-118020690196-3) and supported by a UB RAS Program project.

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