Burst Pressure Prediction of Pipes with SCC Using Intelligent Flaw Interaction Rules

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ABSTRACT

Stress Corrosion Cracking (SCC) often occurs in clusters or colonies containing anywhere from a few cracks to hundreds of individual cracks. Multiple closely spaced cracks may interact, resulting in reduced burst pressure compared to what might be expected from a single crack. Flaw interaction rules are used to capture the impact of multiple cracks on the burst pressure of a pipe. However, most existing flaw interaction rules in standards could contribute to overly conservative burst pressure predictions which can lead to unnecessary hydrotests and/or other remediation actions.

A set of intelligent flaw interaction rules (named the PRCI-CRES intelligent interaction rules, or PRCI-CRES rules hereafter) have been developed. The rules use the principles of equivalent impact and represent the magnitude of the impact of multiple cracks by a single virtual crack. Verifications against full-scale tests show that the PRCI-CRES rules accurately account for the impact of multiple cracks.

This paper starts with a brief introduction to the PRCI-CRES rules and contrasts the new rules with the existing rules in standards. The performance of the intelligent rules is evaluated using three sets of full-scale burst tests. These rules are incorporated into a software tool that integrates the processing of NDT results, application of flaw interaction rules, and selection of fracture mechanics models, including Modified Ln-Sec, CorLAS™, MAT-8 and API 579, for burst pressure prediction.

The predicted burst pressure of SCC colonies is affected by a number of factors, including flaw dimensions and their spatial distribution as reported by different inspection methods, flaw interaction rules, basic material properties such as tensile strength and Charpy impact energy, and fracture mechanics models. This work demonstrates that, among these factors, the selection of flaw interaction rules has the greatest impact on the accuracy of predictions. The PRCI-CRES rules were found to provide the most accurate and precise burst pressure prediction when factors other than flaw interaction rules remain the same.

KEYWORDS

stress-corrosion cracking, burst pressure prediction, flaw interaction rules, SCC cluster, burst tests

INTRODUCTION

Stress Corrosion Cracking (SCC) in pipelines often occurs in clusters or colonies. Flaw interaction rules are used to capture the impact of multiple cracks on the burst pressure of a pipe with SCC colonies. The predicted burst pressure is a key parameter in mitigation decisions in accordance with industry standards such as ASME B31.8S [1].

Flaw interaction rules usually consist of at least two components: (1) a proximity criterion indicating the onset of an interaction and (2) a method to represent the impact of interacting flaws. These are two fundamentally different measures of interaction but are frequently mixed together indiscriminately when flaw interactions are discussed. Existing flaw interaction rules in current standards, such as those in CEPA [2], ASME Section XI [3], BS 7910 [4], and API 579 [5], use the concept of critical spacing to indicate the onset of interactions. The impact of the interactions is represented by having an equivalent flaw which typically has a length equal to the sum of the individual lengths plus the spacing (i.e., an accumulated length) and a depth equal to the maximum depth of all flaws determined to be interacting. While the critical spacing criteria for interactions vary among different interaction rules, the representation of the impact of interaction is quite similar among different interaction rules in current standards.

PRCI-CRES INTELLIGENT FLAW INTERACTION RULES

A fundamentally different approach has been taken in the treatment of flaw interactions in the PRCI-CRES rules.

(1) There is no longer a critical spacing that triggers flaw interaction.