Wang, Y.-Y., Swatzel, J., Horsley, D., and Glover, A., Girth Weld ECA from the Perspective of Code Revisions in North America, Proceedings of 4th International Pipeline Conference, Calgary, Alberta, Canada, 2002, Paper No. IPC2002-27167

Abstract

In North America there are two primary girth weld ECA (Engineering Critical Assessment) codes: API 1104 Appendix A and CSA Z662 Appendix K. Both codes were developed in the early-to mid-1980's and thus represent the technology of that time. Significant progress has been made since then in understanding the structural behavior of girth welds containing welding defects. This paper describes an effort funded by the PRCI (Pipeline Research Council International) to establish the technical basis for the revisions of these codes using the knowledge generated since the inception of the codes. The CSA Z662 Appendix K sets defect tolerance using separate fracture and plastic collapse criteria, while API 1104 Appendix A has only a fracture criterion. The worldwide trend in defect assessment is moving towards FAD (Failure Assessment Diagram) based approach, by which both fracture and plastic collapse can be assessed in one consistent format. An FAD-based ECA procedure specifically tailored to girth welds has been developed in a separate PRCI-funded project. This procedure incorporates refined fracture and plastic collapse solutions and the effects of weld strength mismatch. The experimental verification has shown that the procedure is accurate and can become the basis for future code revisions. As an interim step towards the eventual adoption of a fully FAD-based approach, a number of revisions may be made to the API 1104 Appendix A, including (1) adding a plastic collapse criterion; (2) lowering the minimum CTOD requirement of using Appendix A to 0.003 inch (0.076 mm) from the current minimum of 0.005 inch (0.127 mm); (3) setting the allowable defect length as a continuous function of defect depth (height for buried defects); (4) allowing the use of any valid CTOD toughness greater than a set minimum value; (5) revising the notching procedure for HAZ CTOD testing. These recommendations are interdependent. Selectively adopting any of those recommendations may result in undesirable consequences. For instance, lowering minimum CTOD requirements necessitates the revision of allowable defect height. Adding the plastic collapse criterion would almost certainly require the change of defect length allowance of the fracture criterion from the current step function to a continuous relation. It should be made absolutely clear that lowering the minimum CTOD requirements for using Appendix A does not mean inferior weld quality control. It merely allows the assessment of significance of weld defects using the fracture mechanics methodology that has been proven effective. The interim step for the CSA Z662 Appendix K is revising the plastic collapse criterion. These revisions, when implemented, should result in more consistent degree of conservatism than the current codes. In certain cases, the size of the allowable defects is less restrictive than the current codes while maintaining consistent and adequate safety margin. This should translate to cost savings in both new construction and the maintenance of existing pipelines without sacrificing the safety and integrity of the pipelines.

Keywords

Pipeline, Girth weld, Flaw acceptance criteria, Workmanship, ECA, API 1104, CSA Z662