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Assessment of crack-tip constraint effects on fracture toughness of API 5L X65 steel based on BS 7910 procedures

Paul Sukpe[1,2], Prof. Rade Vignjevic[1], Dr Kevin Hughes[1], Dr Rob Kulka[2]

[1]Brunel University London, Kingston Ln, London, Uxbridge UB8 3PH; [2]TWI Ltd, Granta Park, Great Abington, Cambridge, CB21 6AL

Abstract

Significant efforts have been made in the past decade in fitness-for-service (FFS) and Engineering Critical Assessment (ECA) procedures, that provide a concise framework to relate crack size with applied loading using failure assessment diagrams (FAD) to evaluate the severity of crack-like flaws. These approaches rely in the use of fracture toughness data measured from deeply notched specimens under bend loading to guarantee high levels of stress triaxiality which drive the fracture process. Annex N of BS 7910 procedure describe the methods of including in-plane constraint in the analysis of engineering structures containing flaws that provide conservative acceptance criteria.

Most real structural components such as offshore pipelines have small in-plane or out-of-plane dimensions that could cause a reduction in crack-tip constraint to a sufficient amount leading to an increase in effective fracture toughness of the components. The transferability of experimentally measured fracture toughness data to structural piping components therefore, remains essential in accurate predictions of in-service residual and remaining life of these components.

As part of efforts to validate these procedures for shallow-cracked specimens, fracture tests on API 5L X65 pipe steel for pin-loaded single-edge notch tension (SENT) and three-point single-edge notch bend (SENB) specimens was carried out at room and -120℃. The results were indexed in terms of the fracture parameter J and the constraint parameter, T. The knowledge gained can be used to develop fracture mechanics methodology and selection of suitable specimens for testing of cracked pipes.

Keywords*:* brittle fracture, defects, integrity assessment, low temperature ,shallow-cracked