Master's Thesis

CHARACTERISATION OF THE MORPHOLOGY OF INCLINED SCC CRACKS IN AUSTRALIAN GAS PIPELINES

BY

LUKE ZADOW

B.E., Mechanical Engineering

School of Mechanical Engineering

The University of Adelaide

October 2013

i. Declaration

This work contains no material that has been accepted for the award of any other Degree or Diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent for this copy of my thesis, when present in the University of Adelaide Library, being available for loan and photocopying.

L. Zadow

08/10/2013

ii. Acknowledgements

Special acknowledgements for their contribution to the progress and success of this project as well as their advice and contribution to achieving the results:

- Geoff Callar
- Craig Clarke
- Vijay Vijayaraghavan.

This work was funded by the Energy Pipelines Cooperative Research Centre, supported through the Australian Government's Cooperative Research Centres Program.

The cash and in-kind support from the Australian Pipeline Industry Association Research and Standards Committee (APIA RSC) is gratefully acknowledged.

The author would like to thank Adelaide Microscopy for their generous help and assistance in advising the best approach for achieving optimal results for this project. Their support is highly valued.

The assistance provided by the Mechanical Engineering workshop in the manufacture and preparation of samples for tomography is greatly appreciated. In particular, the assistance of, and advice from, Richard Pateman is acknowledged.

A special thanks to Valerie Linton and Erwin Gamboa for their advice on the direction of this project, which ensured its success.

The author would like to thank Michael Giuliani for his contribution to the project with his knowledge in the area of tomography.

The author would also like to thank his mother and family for their support and help with editing this thesis and other reports.

iii. Publications from Thesis

Zadow, L & Gamboa, E 2012, 'Tomography of Inclined SCC Cracks in Australian Gas Pipelines', *Proceedings of the 9th International Pipeline Conference*, IPC2012 - 90363

Zadow, L Gamboa, E & Lavigne, O 2013, 'Morphology of Australian Inclined SCC', *Corrosion Science*, (in progress).

Zadow, L Gamboa, E & Lavigne, O 2013, 'Comparison of Inclined SCC between Canada and Australia', *Corrosion Science*, (in progress).

iv. Abstract

Stress Corrosion Cracking (SCC) in pipeline steel occurs when an aggressive environment and tensile stresses act on a susceptible microstructure. Typically, SCC in gas pipelines tends to travel perpendicular to the hoop stresses in the through-wall direction. Studies conducted on the TransCanada pipeline, where a rupture had occurred, revealed the incidence of SCC cracks, whose crack path deviated at an angle from the normal. These unusual inclined cracks have also been found in an Australian pipeline, resulting in a need for a more comprehensive understanding of inclined SCC.

As a result, this study has been undertaken to investigate SCC in Australia, in particular the morphology of inclined SCC and together with the many inclined crack features and crack interactions and anomalies (inclusions) in the pipe steel. This study revealed that 81% of SCC cracks investigated were inclined. The majority of cracks analysed were over 4 mm in length, which corresponded to the calculated critical crack length according to industry guidelines. Inclined cracks morphologically presented with a straight section before they inclined away from the perpendicular direction. The straight section tended to be between 200-900 µm and the inclination angle varied between 30-60^{o}. This inclination angle increased as the crack grew deeper into the pipe wall, resulting in long cracks travelling a considerable distance in the hoop direction (3.8 mm travel for a 51 mm longitudinal surface SCC crack). In two cases (out of 120 cracks), subsurface longitudinal crack travel was observed to be approximately 1.5 mm. In most other cases, no subsurface longitudinal travel was observed.

Observed crack interactions did not breach current industry guidelines used for SCC threat assessment. Hence, procedures currently employed for critical crack assessment are still deemed valid and conservative enough for Australian operations.

Keywords: Stress Corrosion Cracking, Tomography, Pipeline Steel

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ix. Nomenclature

Term	Description
CC	Confirmation colony
CP	Cathodic protection
CT	Computed tomography
DC	Direct current
FC	Fatigue colony
FOV	Field of view
ID	Inner diameter
IG	Intergranular
LC	Leaking colony
M–S	Moomba to Sydney
MPI	Magnetic particle inspection
NN	Near neutral (pH)
OD	Outer diameter
SCC	Stress corrosion cracking
SIF	Stress intensity factor
SS	Straight section
SMYS	Specified minimum yield strength
TC	Teething colony
TG	Transgranular
UoA	University of Adelaide