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MEASUREMENT OF FLAW GROWTH IN ELECTRIC RESISTANCE WELDED PIPE SEAMS FROM MULTIPLE PRESSURE TESTS AND HOLD TIME AND IMPLICATIONS ON MANAGING PRESSURE REVERSALS IN HYDROSTATIC TESTS

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ABSTRACT

The presence of low frequency (LF) ERW seam weld defects (e.g., lack of fusion, stitching, and hook cracks) can reduce the pressure-carrying capacity of a line pipe. In cases where these defects may have been subjected to a hydrostatic test, there is a possibility that the seam weld defects could fail at a lower pressure upon re-pressurization. This type of failure, which occurs at a pressure less than the previous pressure and where no time dependent degradation has contributed, is commonly referred to as a pressure reversal.

LF ERW seam flaws can fail when held at a constant load below the straight-off to failure load. This is because ductile materials can exhibit time-dependent creep behavior. Evidence of time dependent behavior is provided by failures that occur during the maximum pressure hold period of a hydrostatic test.

Time dependent growth and reverse yielding can be detrimental when performing multiple high pressure hydrostatic tests which can result in many blowouts during the hydrotests, and flaws that survive the hydrotest may experience some ductile tearing that could be detrimental to fatigue life.

The objectives of the work described in this paper are to:

1) Develop a testing methodology to measure the time dependent growth of vintage LF ERW bondline flaws from actual test samples, at elevated stress levels as well as stress reversals (creep and pressure reversals). The testing would be analogous to pressure testing,
2) Perform a series of tests to measure the growth of flaws via CMOD from a 25% wt (wall thickness) EDM notch placed within the bondline or HAZ of vintage LF ERW seams, and
3) Produce a dataset of physical results that can be utilized to develop a model which can predict the growth of typical ERW flaws such as hook cracks and lack of fusion, as a function of hoop stress and stress reversals. This model could then be utilized to optimize pressure testing in the future to minimize any detrimental effects of flaw growth that could reduce fatigue life.

A testing methodology consistent with the objectives was developed to measure creep associated with hold periods at elevated stresses (pressures) and pressure reversals. This testing methodology covers the following items:

1) The sample size, flaw size and overall configuration for loading and measurement with CMOD.
2) The straight-off to load failure stress and CMOD at a load rate consistent with pressure testing.
3) The loading steps and associated hold periods based on a fraction of the straight-off to load failure.
4) Cycles to zero and back to load to observe the effect of stress reversals.

The methodology was successful in showing the time-dependent growth of the flaws at elevated loads, as well as establishing that after reducing the pressure down to zero and back to load, the time dependent growth could be re-activated. The results of the various tests performed are presented in this paper.

Keywords: vintage pipeline, low frequency ERW, cold weld, hook crack, pressure reversal, time dependent creep

NOMENCLATURE

AYS	Actual Yield Strength
CMOD	Crack-Mouth Opening Displacement
CVN	Charpy V-Notch
CWT	Cross-Weld Tensile
EDM	Electrical Discharge Machined
ERW	Electric Resistance Weld
FEA	Finite Element Analysis
PRCI	Pipeline Research Council International
SMYS	Specified Minimum Yield Strength
Y/T	Yield Strength to Ultimate Tensile Strength Ratio
a, Δa	Crack Depth, an Incremental Increase in a
E	Elastic Modulus
σ_{max}	Maximum Stress in Specimen Net Section during the Straight-Off to Failure of the Notched Specimen
LF ERW	Low Frequency Electric Resistance Weld
wt	Wall Thickness
W	Specimen Width
a/W	Normalized Crack Depth by Specimen Width