PROCEEDINGS PAPER

INCEFA-SCALE TEST DATA COMPARED TO ENVIRONMENTAL FATIGUE DESIGN CURVE METHODOLOGIES

Authors:
Jack Beswick (Amentum, Warrington, UK), Alec McLennan (Amentum, Warrington, UK), Chris Currie (Rolls-Royce, Derby, UK), Stephan Courtin (EDF R&D, Saclay, France)

Proceedings of the ASME 2025 Pressure Vessels & Piping Conference (PVP2025)
July 20-25, 2025, Montreal, Quebec, Canada

Paper No.: **PVP2025-154594**; 11 pages
DOI: 10.1115/PVP2025-154594
Published Online: October, 2025 (*expected*)
URL: https://asmedigitalcollection.asme.org/

Abstract:

INCEFA-SCALE is a five-year project supported by the European Commission HORIZON 2020 programme. It is the successor to the INCEFA-PLUS programme that ran from 2015 to 2020. INCEFA-SCALE began in October 2020. Its objective is to work towards the ability to predict lifetimes of Nuclear Plant components when subjected to Environmentally Assisted Fatigue loading. This paper focuses on the analysis of data produced during the uniaxial testing programme of INCEFA-SCALE.

The basis of the ASME BPVC Section III stainless steel fatigue design curve is the mean air fatigue curve, derived from laboratory tests on uniaxial specimens with standard fully reversed loading. This curve is then modified for mean stress and adjusted using factors on both stress/strain or life by transference factors accounting for various deleterious effects, with the worst case defining the design curve. Research studying the interactions between the adjustment factor of 2 on stress or strain, and environmental effects, have the potential to have a highly beneficial outcome for operators and manufacturers of Pressurised Water Reactor (PWR) plant, because transient loading in this regime accounts for an appreciable amount of many components' lives. However, this research requires augmentation with data investigating interactions between loading history, environment, and surface finish to provide a solid technical justification. A reduction in the factor of 2 would result in a larger proportion of these transients falling below the threshold for being included in an analysis, offering assessment, repair, and downtime cost benefits.

INCEFA-SCALE aims to support this international research by investigating loading history and surface finish effects, through the application of standard and variable amplitude waveforms to uniaxial fatigue specimens in air (20 °C and 300 °C) and simulated PWR primary coolant (300 °C). The specimens will have two surface finishes: polished and rough to align with the previously published INCEFA-PLUS programme. By comparing reference data generated using triangular or sawtooth waveforms to the complex loading and rough surface finished specimens, it is possible to isolate the effects and cross examine where relevant for explaining the fatigue life of the specimens.

This paper presents test data from the project against fatigue design curves based on the method defined in the ASME BPVC, with the transference factors from the mean curve, on both stress and cycles, modified to illustrate how the current design approach accounts for the effects studied. This analysis is coupled with environmental factor methodologies including that from NUREG/CR-6909, Rev. 1 and those presented in more recent code cases. Comment is provided on the representation of the data by these modified design curves including potential conservatisms or non-conservatisms with the current approach.

Keywords: environmental fatigue, variable amplitude loading, design fatigue curves

This project has received funding from the Euratom Research & Training programme 2019-2020 under grant agreement N^{o} 945300