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TITLE:
A Comprehensive Review of Forecasting Models for Predicting Service Life of Polyethylene Piping for Nuclear Safety-Related Applications

ABSTRACT:
The ASME Boiler and Pressure Vessel Codes Committee (BPVC) has published Code Case N-755 that describes the requirements for the use of PE pipe for the construction of Section III, Division 1 Class 3 buried piping systems for service water applications in nuclear power plants. The code case was developed by Special Working Group–PE Pipe (SWG-PP) within Section III (Design) of the BPVC. The US Nuclear Regulatory Commission (USNRC) has not as yet approved this Code Case for use in regulatory decisions. However, two Relief Requests for installation of PE Piping in safety-related applications at US Nuclear Power plants have been approved by the USNRC.

The three major failure modes for PE Piping are (i) 'ductile' failure due to overload, (ii) 'brittle' or slow crack growth (SCG) failure due to the effect of long term sustained loads, and elevated temperatures and stress concentrations, and (iii) rapid crack propagation or catastrophic failure at very low temperatures, internal pressure and usually third party "impact" damage to the piping system.

The paper focuses on the susceptibility of PE pipe to premature failure due to SCG - specifically, the various forecasting models and accelerated testing protocols that are used to analyze short term experimental results to predict long term (50 years and beyond) service life. The models most commonly used for this purpose include the rate process method (RPM), the bi-directional shift approach, the correlation between PENT results and service life, and a procedure to integrate SCG initiation and propagation processes to predict failure times. A critical review of these models with regard to the acceleration factors for temperature, stress, and stress intensity factors is provided in the paper. Following this, the predictions of various forecasting models are compared with experimental data. Areas where improvements are needed in these forecasting models for newer generation PE100 or PE4710 bimodal resins are identified.