

Hydrogen concentration Profile Prediction in Pipeline Steels: A Finite Element Modelling Approach Based on Experimental Diffusion Coefficients

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The accurate determination of hydrogen diffusion coefficients in pipeline steels is essential for predicting hydrogen distribution and assessing material performance in hydrogen-rich environments. This study focuses on measuring the hydrogen diffusion coefficient in commonly used pipeline steels (such as API 5 CT T95, P110 and API 5L X60) through electrochemical permeation tests performed according the Devanathan-Stachurski technique [1].

To extend the understanding of hydrogen diffusion beyond experimental measurements, Finite Element Modelling (FEM) was employed to study hydrogen concentration profiles within steel samples under various charging scenarios. The FEM simulations incorporated the experimentally derived diffusion coefficients, allowing for accurate prediction of hydrogen distribution profiles as a function of time and environmental conditions [2].

The combined experimental and numerical approach enables optimization of pre-charging conditions and helps in the evaluation of hydrogen embrittlement risks by providing detailed insights to improve material selection, design, and integrity management strategies for pipelines operating in hydrogen-containing service environments.

[1] Paterlini L, Vergani L, Ormellese M, Curia A, Re G, Bolzoni F. Hydrogen Embrittlement of a T95 Low-Alloy Steel Charged by Electrochemical Method. *Materials*. 2025; 18(5):1047. <https://doi.org/10.3390/ma18051047>

[2] Gritti L., Coffetti D., Cabrini M., Pastore T. A novel approach for estimating hydrogen uptake and diffusion coefficient. *International Journal of Hydrogen Energy*, Volume 112, 2025, Pages 347-353, ISSN 0360-3199, <https://doi.org/10.1016/j.ijhydene.2025.02.400>