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Hydrogen Embrittlement in Pipeline and Cast Steels for Gas Transport Infrastructure

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Using hydrogen/natural gas mixtures or pure hydrogen instead of natural gas is a key approach to industrial decarbonization, reducing greenhouse gas emissions and fossil fuel consumption. Given the extensive gas network, these mixtures are expected to be transported using existing infrastructure.

Natural gas pipelines consist of various components, including pipes, valves, and flange joints. Pipes are typically made of API 5L steels, which are formed during manufacturing, whereas gate valve bodies are made from cast structural steels. These materials have different microstructures, affecting their resistance to hydrogen embrittlement (HE). Cast steels contain micropores and defects that trap hydrogen and increase HE risk.

Two steels were selected for testing: X52, used for pipeline pipes in a formed state, and 1.0619+N, a cast steel used for gate valves. Both were subjected to electrolytic hydrogen charging in sulfuric acid electrolyte with CH_4N_2S as a hydrogen poison. Hydrogenation lasted up to 48 hours, followed by notch impact testing and hydrogen content analysis.

Initial hydrogen content ranged from 1.14 to 1.42 ppm. For 1.0619+N steel, impact energy decreased from 65 J to 50 J, while hydrogen content increased to 12.81 ppm after 24 hours. Fractographic analysis of fracture surfaces provided insights into failure mechanisms in different structural states.

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