COMPARISON OF J-R TEST TECHNIQUES UNDER GASEOUS HYDROGEN ENVIRONMENT

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To ensure the pipeline integrity and demonstrate the readiness for hydrogen transportation, the degradation of materials exposed to H2 gas shall be experimentally evaluated. One of the material properties that is significantly affected by H2 exposure is the fracture toughness. Although, different options exist (i.e., constant loading/displacement, stepping loading, rising loading, etc.), J-resistance curve testing at slow displacement rates is being identified as the most suitable test for fracture toughness determination of steels working in gaseous hydrogen environments. The J-R curve testing following ASTM E1820 procedure has been extrapolated to tests in pressurized H2 conditions. Despite being a standard test, the J-R curve under hydrogen environment from an execution point of view has a complex protocol and requires the precise measurement of the testing variables and rigorous control during the test.

Following ASTM E1820 the J-R curve can be carried out through DC or AC Potential drop, unloading compliance, and Normalization method. All those test methods have performed good correlation results, however, when working at 200 bars H2 gas pressure some issues must be considered to avoid significant errors. In this paper a comparison of different techniques involved during the testing is presented, in particular for the measurements of the load and crack growth during fracture toughness test.

After manufacturing a specific Ti alloy clip-gauge and installing one load cell inside the autoclaves, tests with C(T) specimens were carried out monitoring Load Line displacement, Direct Current Drop Potential, Cross-Head displacement, and the Load inside and outside the autoclave at 200bar of gaseous Hydrogen. The results indicated non-conservative errors when the measuring method is applied just outside the autoclave and the effect of low temperature or pressure fluctuation for that case. Hence, when all measurement instruments are outside the autoclave (room pressure), the friction effect must be minimized and the test must be previously calibrated with measurement instruments inside the autoclave to compensate for those errors.