In-Situ Hydrogen Analysis in Weldments: Novel NDE for Weld Inspection

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O P S A C C O M P L I S H M E N T S

Pipeline Safety Research and Development for Weld Inspection and Assessment of High Strength Pipeline Steel

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Challenge

With use of pipeline steel and steel weldments of increasing strength, the critical hydrogen concentration for hydrogen cracking is being significantly reduced. The assessment of hydrogen content in pipeline steel and its weldments is an essential requirement to monitor loss of integrity of the pipeline and to prevent failures. Non-destructive, non-contact hydrogen sensors using low frequency impedance have been developed to provide real-time hydrogen content measurements on in-service pipeline steel and steel weldments. The low frequency impedance hydrogen sensor must be sensitive only to hydrogen, while other factors such as microstructure, temperature, pre-existing magnetic remanence should be negligible as seen in Figure 1.

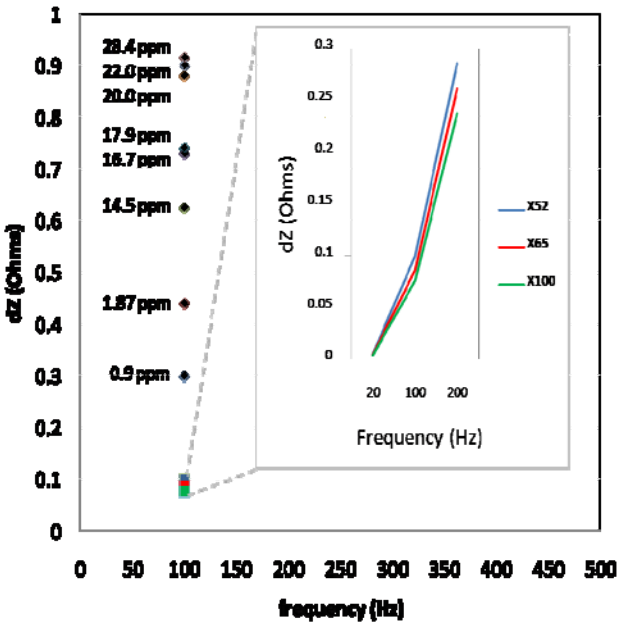

Figure 1: Low frequency impedance as a function of hydrogen content for hydrogen charged X80 linepipe steel specimens. *Embedded figure is low frequency impedance as a function of pipeline microstructure (X52, X65, X100).*

Accomplishments

- **Successfully developed new field non-destructive hydrogen content sensors through use of soft ferrite cores and permanent magnetic yokes.**
- **Successfully developed field non-destructive hydrogen content measurements through various pipeline coatings.**
- **Successfully achieved non-destructive hydrogen content measurements immediately following welding.**

Technology Objectives

1. **Simultaneously assess hydrogen solute content, aging due to hydrogen, and microstructure changes during weld fabrication in high strength steel pipe and weldments.**
2. **Non-contact measurement of weld metal hydrogen content and microstructural characterization through coatings for rapid hydrogen content assessment in high strength steel weldments.**
3. ***In-situ* measurement during hydrogen-assisted fatigue testing at NIST-Boulder to allow for real-time assessment of the dynamic effects of hydrogen in high-strength steel and welds.**

Office of Pipeline Safety

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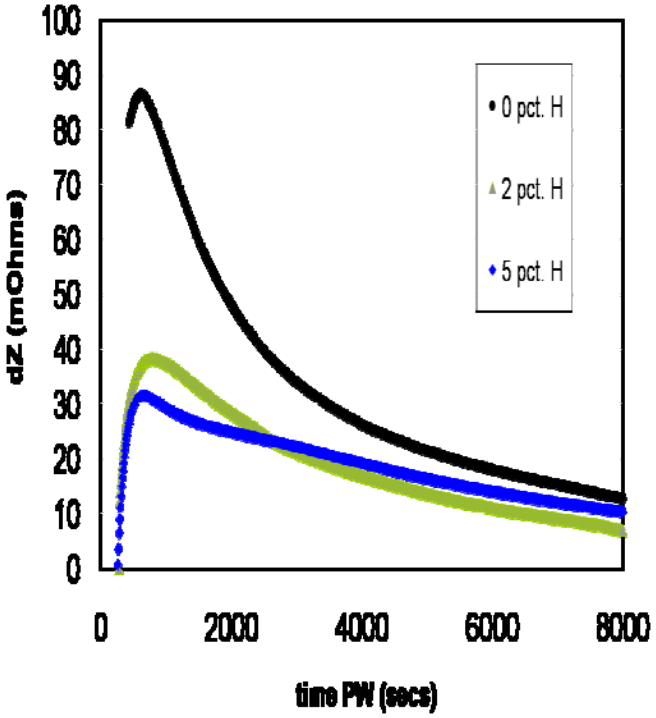

Figure 2: Change in low frequency impedance as a function of time (as hydrogen diffuses out) for X100 steel pipeline weld specimens.

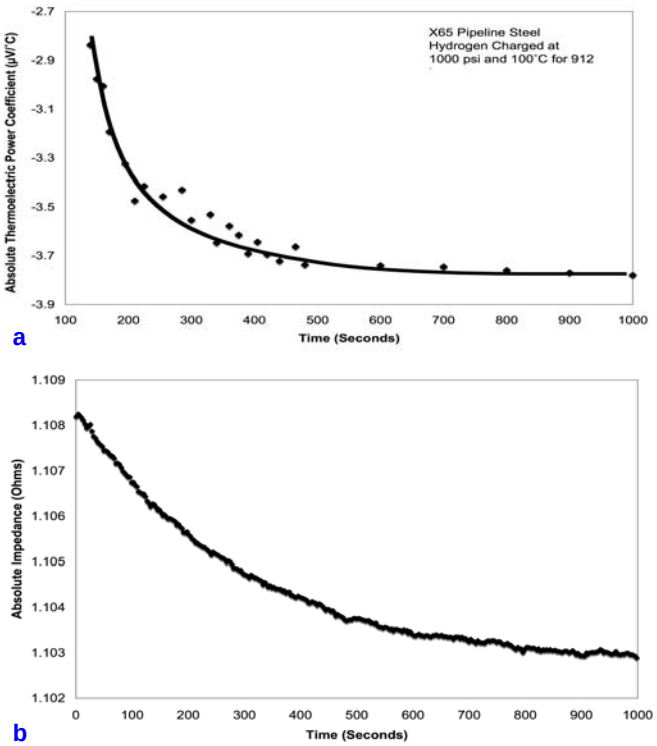

Figure 3: (a) Thermoelectric power coefficient as a function of time (as hydrogen diffuses out) and (b) low frequency impedance as a function of time (as hydrogen diffuses out) for a gaseous hydrogen pre-charged X65 steel pipeline specimen.

Benefits

This research will advance the safety of future and existing pipelines by providing a non-destructive, non-contact assessment of hydrogen content in pipeline steel before significant hydrogen accumulates in the steel or weldments. The non-destructive hydrogen sensing system is available to be used during manufacturing, processing, and service (through pipeline coatings) of the pipeline.

Future Activities

Future activities focus on complete calibration of the non-destructive hydrogen sensor probe for in-service pipeline measurements, which accounts for microstructure and temperature of the steel, the applied coatings type and thickness, and magnetic remanence level.

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