An Assessment of Magnetization Effects on Hydrogen Cracking for Thick-Walled Pipelines

(Annual Progress Report)

by

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EXECUTIVE SUMMARY

The pipeline network in the Beaufort Sea of Alaska is designed conservatively to protect against unconventional matters and it requires a high level of confidence and reliance on inspection techniques such as the Magnetic Flux Leakage (MFL). This technique is performed by magnetizing the pipe wall and then detecting a local flux leakage caused by anomalies relative to changes in the pipe wall thickness. It was theoretically demonstrated that the diffusible hydrogen content in steels would be significantly affected by a magnetic induction. In other words, the magnetization produced during pigging operations would notably have a significant effect on the hydrogen concentration in pipeline steels, therefore potentially enhancing the hydrogen-cracking phenomenon.

To evaluate how a strong magnetic flux density produced during recurrent pigging routines affects the hydrogen-induced cracking susceptibility of thick walled and high-strength pipeline steels, four fundamental variables have been defined. These variables are pipeline steel grade, wall thickness, residual stress effect, and magnetic flux density. The experimental approach plans to use three steel grades: X52, X70, and X80. The wall thickness range goes from $^{5}/_{16}$ to ¾ inches (7.94 to 19.0 mm). Test specimens are sectioned from cold-worked tensile test samples loaded at different elongation levels. The selected magnetic flux density levels are the saturation and remaining induction.

Since August 1st 2003, nine of the fifteen total research tasks have been completed to date. A future work section is included in this annual report describe the experiments that will be done and presented in the final project report.

Early interpretation of results reveals progress in the extraordinary effect of saturation magnetic induction on the absorbed hydrogen concentration in pipeline steels. To be precise, a magnetic flux density of 20,000 Gauss increases in more than nine times the absorbed hydrogen concentration in the tested steel. Furthermore, the remanence magnetic induction increases approximately three times the absorbed hydrogen content.

The preliminary experimental approach brings to light the fact that the magnetic induction generated by MFL inspection tools considerably affects the hydrogen content in pipeline steels. Further tests will bring more evidence to this assessment. Adsorbed hydrogen concentration (total hydrogen content) tests will be run for higher strength steels and their mechanical properties will be compared under varied laboratory conditions.

In steel, as the strength increases, the allowable diffusible hydrogen content decreases, making the steel more susceptible to hydrogen assisted cracking. In this report, it is shown that the magnetic flux density of 20,000 Gauss increases by more than nine times the absorbed hydrogen concentration. Therefore, the need for new approaches for hydrogen management needs to be addressed. In Appendix A, an electronic approach utilizing the thermoelectric power coefficient to evaluate hydrogen content in pipeline steels is introduced and described.

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