Secat, Inc.

Materials Solutions for Hydrogen Delivery in Pipelines

Project Summary

Pipeline transmission is the most economical method for hydrogen delivery in large quantities from the point of generation to point of use. Literature to-date clearly shows that hydrogen embrittlement of pipeline steels is one of the limiting factors in the cost-effective, high-pressure transport of hydrogen. Over the past few years, significant advances have been made in understanding the mechanisms of hydrogen embrittlement in a wide variety of materials. Furthermore, integration of computational techniques with experimental methods has resulted in the development of “designer” materials along with the scientific methodologies for developing customized materials better suited for any given application. We strongly believe that revolutionary advances are now possible in addressing the problem of hydrogen embrittlement of steels. This proposal presents an integrated approach to developing and testing new materials solutions to enable pipeline delivery of hydrogen at high pressures. The proposed work addresses Topic 8, Sub-Topic 8A- Pipelines R&D.

Two potential solutions to mitigating the hydrogen embrittlement of steels are outlined in this proposal- 1. Development of barrier coatings and in-situ deposition processes suitable for the protection of existing gas pipelines and newly added pipelines, and 2. Development of new alloys that have a better resistance to hydrogen embrittlement. This work proposes to deliver solutions that can be readily deployed by incorporating materials development, materials testing and evaluation, and materials adoption. A key enabler in this work is the use of a novel rapid mechanical testing tool, Stress-Strain Microprobe, that will reduce the time and cost involved in testing the effect of high-pressure hydrogen on the mechanical properties of materials. Properties of base materials, weld metal, and heat-affected zone will be addressed in this work. Advanced coating technologies will be adapted for the development of new barrier coatings, thus minimizing development time. Computational tools such as ThermoCalc™, neural networks, and codes being developed by the University of Illinois to predict lifetimes of pipeline steels, will enable the development of new alloys with better resistance to hydrogen embrittlement and hence will be crucial to this project.

The team assembled for this project is exceptional, diverse, and comprises of a national laboratory, industries, an engineering organization, and a university, all being leaders in their field. Oak Ridge National Laboratory has many on-going programs on coatings and alloy development, and is one of the few national laboratories that have the expertise and equipment to perform specialized research in this area. Companies such as Advanced Thin Films Inc., Chemical Composite Coatings International (C3), and SCHOTT North America will enable the development of specialized barrier coatings. Advanced Technology Corporation, the inventor of the Stress-Strain Microprobe system for in-situ mechanical property testing of pipeline steels, has significant experience in pipeline

testing methodologies. SECAT, ORNL, and Columbia Gas Company will address issues related to the cost of commercial adoption of the technology for pipeline networks and the avenue by which cost targets can be met. University of Illinois has a strong tradition of performing fundamental research in materials science, and particularly in the area of hydrogen embrittlement of materials. Input from the university project “Hydrogen Embrittlement of Pipeline Steels: Causes and Remediation,” will also be a key aspect of this collaborative work. American Society of Mechanical Engineers (ASME), an active participant in this proposal, with its diverse groups of technical experts will enable formation of technical committees to peer-review the research program, will serve as a valuable technical resource for the program, and may also facilitate incorporation of significant research results into the codes and standards for hydrogen infrastructure development. Successful alloy compositions will be transferred to NAPA Pipe Corporation, another team-member, for commercialization.

Our focus during this work is to enable the reduction in capital cost of hydrogen pipelines. Estimates show that the capital cost associated with the construction of a high-pressure hydrogen pipeline is $ 1.4 million/mile in 2003 and the DOE targets established for 2005 for trunk lines is $1.2Million/mile (14.2% reduction) and for 2010 it is $600K/mile (57% reduction). As part of this work, with the help of Hatch Moss MacDonald a pipeline service company with expertise in the construction and maintenance of pipelines, we will develop a cost breakdown of hydrogen pipeline construction and evaluate the cost savings feasible along with a path to achieve these cost savings. We will also estimate the costs of the proposed technologies and compare it with the desired costs. Our target is a 20-40% cost reduction by 2007.