

Reducing Hydrogen Permeation

Alonizing the surface of a steel substrate is very effective in reducing hydrogen permeation, especially when both the inner and outer surfaces of the steel are processed. Evidence suggests that Alonized ferritic and austenitic steels reduce hydrogen permeation by three orders of magnitude compared to untreated alloys of the same composition.

Example #1: Hydrogen permeation is also related to other types of degradation, such as stress corrosion cracking and hydrogen blistering. In "Sulfide Stress Cracking Studies on Aluminized Steels," Dr. L. H. Gundiler (New Mexico Institute of Technology) states: "since Al has a very low hydrogen permeability coating with Al will act as a hydrogen barrier and is expected to decrease SSC susceptibility". Dr. Gundiler's studies were carried out on dip aluminized substrates, which develop a thin intermetallic layer. When the surface aluminum is lost, the intermetallic layer remains effective. His report further states (p. 63): "Both aluminum layer and the iron-aluminum intermetallic layers have hydrogen permeability rates several orders of magnitude less than that of iron. Consequently, aluminizing produces an excellent barrier for hydrogen diffusion and prevent (hydrogen induced) sulfuric stress cracking (SSC) failure of high strength steels."

Example #2: Alonizing reduces the permeation of deuterium through an austenitic or martensitic steel substrate. One study (K.C. Forcey, D.K. Ross, J.C.B.

Simpson, and D.S. Evans, Journal of Nuclear materials, 160 (1988) 117) found that the permeation rate of tritium through Alonized material was nearly four orders of magnitude lower than through untreated steel. The authors inferred from this data that permeation of tritium through Alonized martensitic and austenitic steel coupons would also be greatly reduced, particularly at the operating temperature range to 600°C (1100°F) being considered for use in the NET (Next European Torus) blanket.

Example #3: A bayonet-type heat exchanger in which a heating medium was losing sensible heat through the annulus between the inner tube and outer tube. It was postulated that hydrogen diffusion through the wall of the inner tube into the annulus was providing a means for conducting heat from the inner tube. Thereby reducing the temperature of the heating medium and causing the failure.

The metallurgy of the inner tube was a low-chromium ferritic steel, API 5-A grade N-80. A section of this tube was Alonized inside and out and tested for hydrogen permeation by the designer, a major industrial firm in the United States. It was found that the double Alonized surface reduced total hydrogen permeation by almost three orders of magnitude. The entire heat exchanger (over two miles of pipe) was then Alonized. The process worked under this new configuration to its theoretical design efficiency.

Endurance Technologies Contact Information

Jim Wyatt
7940-56th Street S.E.
Calgary, Alberta, Canada
(403) 236-6081
jim.wyatt@endurancetechnologies.com
www.endurancetechnologies.com