SUMMARY AND CONCLUSIONS

Studies were conducted to define the kinetics involved with the stress dependent reversibility of the incubation period which occurs in the delayed failure of hydrogenated high-strength steel. Specimens were stressed for a time which was 0.8 of the original period required for crack initiation. The stress was then removed and the specimens aged for various times and temperatures. When the stress was reapplied the incubation period varied directly with the aging variables. Aging times of 150 min at 75°F or 6 min at 252°F produced full recovery of the incubation period indicating that this parameter was truly reversible with respect to the applied stress. The kinetics involved in the recovery of the incubation time could be directly related to the diffusion of hydrogen in the lattice. The activation energy for the recovery process was approximately 9000 cal per mole which is equal to the activation energy for the original crack initiation process and the diffusivity of hydrogen in the lattice. Using a simple cylindrical model for outgassing the effective diameter over which the stress-induced hydrogen movement occurred was calculated as approximately 0.014 in.

Reversible hydrogen embrittlement at liquid nitrogen temperatures was also observed in cathodically-charged high-strength steel specimens. Embrittlement, as measured by a decrease in reduction of area, was present at hydrogen concentrations in the range of 5 to 8 ppm. However, even in embrittled specimens the reduction in area was approximately 5 pct indicating that considerable void coalescence was required prior to fracture.

The results of both the reversibility and low temperature experiments supported the lattice embrittlement theory proposed by Troiano.[1] Neither the pressure theory nor the adsorption theory could properly account for the kinetics involved in the reversibility of the incubation period or the presence of low temperature embrittlement where diffusional processes should be negligible.

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