Hydrogen Embrittlement

Hydrogen embrittlement of structural metal components is a well-known phenomenon in hydrogen gas containment applications and an important consideration in any project involving the use of hydrogen. The physics of hydrogen embrittlement involves hydrogen gas molecules contacting the metal surface, which can catalyze the molecules to dissociate into individual hydrogen atoms. The hydrogen atoms can then easily permeate into the metal and interact with material defects. These interactions can accelerate the formation and growth of cracks, causing premature failure of the component. For example, hydrogen embrittlement was implicated in the failures of steel bolts during the construction of the eastern span of the San Francisco-Oakland Bay Bridge in 2013. While steel bolts serve as a prominent reference point, hydrogen embrittlement can be activated in most structural metal components exposed to hydrogen-producing environments.

Codes and standards addressing hydrogen embrittlement are still evolving owing to the complexity of the subject. That complexity is due to the three variables that govern hydrogen embrittlement: material characteristics (e.g. strength), stress levels in the component as a function of time, and environmental parameters (e.g. pressure and temperature). When hydrogen embrittlement is addressed in codes and standards, it is imperative not to extrapolate the guidance beyond the intended application envelope which means that sometimes concrete guidance is lacking. If this is the case, then subject matter experts should be consulted. These experts often rely on the successful hydrogen service experience of structural metal components as well as data from materials testing to render judgments on managing hydrogen embrittlement.

Read more about this and other hydrogen safety topics at www.h2tools.org.
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