



Technical Bulletin

#115

Volatile Corrosion Inhibitors (VCI) and Hydrogen Embrittlement

ARMOR Volatile Corrosion Inhibitors (VCIs) can reduce a metal's susceptibility to hydrogen embrittlement. ARMOR VCI molecules attach themselves to metal surfaces forming an invisible thin film. The VCI film will passivate the substrate, inhibit oxidation, and provide a barrier on the metal surface. This leads to a reduced susceptibility to hydrogen embrittlement.

What is Hydrogen embrittlement?

Hydrogen embrittlement is the process where metals become brittle following exposure to hydrogen. Hydrogen is first adsorbed onto the metal surface before penetrating the metal lattice in ionic form as protons. Hydrogen protons re-combine in lattice dislocations (micro voids) forming hydrogen molecules. The hydrogen molecules are unable to diffuse out of the metal matrix and will build pressure inside the micro voids. This hydrogen pressure will cause a marked loss in the plastic strain capacity of the metal, reducing the ductility and tensile strength.

Hydrogen embrittlement can occur during manufacturing processes, storage, or operational use - anywhere that the metal comes into contact with atomic or molecular hydrogen. Common ways in which hydrogen is introduced to the metal matrix include corrosion, chemical reactions on the metal surface, and contact with acids or with other chemicals such as hydrogen sulfide or even water.

How do Volatile Corrosion Inhibitors work?

ARMOR has engineered highly specialized corrosion inhibitors based on aliphatic and nitrogen containing salts. The salts disassociate to form ions, permeating the packaging environment with corrosion inhibitors. The inhibiting ions are attracted to and deposit on metallic surfaces displacing moisture in the process and re-associating to form a stable nano-coating only a few molecules thick.

Components in ARMOR VCIs reduce the activity of hydrogen in the environment and on the metal substrate. Nitrogen-containing organic and inorganic compounds inhibit hydrogen from forming ionic protons. VCI molecules passivate the metal surface neutralizing the effects of chemical contaminants. ARMOR VCI nano-coating also forms an effective barrier to help prevent hydrogen donating chemicals from coming in contact with the metal substrate.

References

Kobrin, G. Metals Handbook, Vol. 13, Corrosion, 9th Edition. Metals Park, OH. ASM International, p. 321, 1986.

Raymond, Louis. Hydrogen Embrittlement: Prevention and Control. Philadelphia, PA. ASTM, 1988.

R K Dayal and N Parvathavarthini. Hydrogen embrittlement in power plant steels. Indira Gandhi Centre for Atomic Research, Kalpakkam 603 102, India *Pp448-449*

Sylvain Audisio. Multimedia Corrosion Guide. Laboratoire de Physicochimie Industrielle INSA LYON

U. Etzold, K.P. Mohr, P. H.Iser. The Use of Corrosion Inhibitors in Steel Strip Production and Coating (Thyssen Krupp Stahl AG, SurTec GmbH)

Published by: ARMOR Protective Packaging Technical Services, March 10, 2011

F:Product Standards/Technical Bulletins