CORROSION TYPES
CHAPTER 4
11) HYDROGEN DAMAGE

LECTURER
SAHEB M. MAHDI
11) Hydrogen Damage

It is a general term which refers to mechanical damage of a metal caused by the presence of, or interaction with, hydrogen.

Hydrogen damage may be classified into four distinct types:
- hydrogen blistering.
- hydrogen embrittlements.
- decarburization.
- hydrogen attack.

**Blistering**

Hydrogen enters the lattice of a metal, diffuses to voids, creates high internal stresses → blisters . . .

Blistering may occur during exposure to:
- hydrocarbons;
- electroplating solutions;
- chemical process streams;
- pickling solutions;
- H-containing contaminants during welding;
- general corrosive environments.

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Cross section of a carbon steel plate removed from a petroleum process stream showing a large hydrogen blister. Exposure time: 2 years.

**N.B.** The mechanism of hydrogen uptake by metals must involve atomic hydrogen - molecular hydrogen cannot diffuse through metal lattices. BUT . . . remember that molecular hydrogen may absorb and dissociate on metal surfaces.
Prevention of Blistering

► use steels with few or no voids; (Killed steel instead of rimmed)
► use coatings; (Metallic, inorganic and organic coatings, cladding, rubber and plastic coating and brick linings).
► use inhibitors
► remove poisons; (impurities that can promote hydrogen evolution. \(\text{S}^2\) (particularly bad), As compounds, \(\text{CN}^-\), etc.
► use different materials (Ni-base alloys have low diffusion rates for hydrogen).
Hydrogen Embrittlements
Similar to blistering . . . hydrogen enters metal lattice . . .
BUT . . . interaction with metal lattice different. High-strength (and more brittle) steels are susceptible. H-embrittlements different from SCC in nature of cracks . stress-corrosion cracks usually propagate anodically;

Direction of advancing cracking into metal

Anodic stress corrosion cracking
Hydrogen embrittlement

Region of anodic stress corrosion cracking
Region of immunity
Region of hydrogen embrittlement

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Prevention of Embrittlement

- reduce corrosion rate (inhibitors, coatings, etc.).
- change electroplating process to minimize H effects (voltage, current density, bath composition, etc.).
- bake material to remove H; (200-300 °F).
- minimize residual stresses; (annealing).
- use less susceptible material; (Alloying with Ni or Mb).
- maintain clean conditions during welding; (Dry condition).

Decarburization and Hydrogen Attack

High temperature process - C or carbide in steels can react with gaseous hydrogen

\[ C + 2H_2 \rightarrow CH_4 \]

Note that the reaction can occur with atomic H in the metal lattice . . .

\[ C + 4H \rightarrow CH_4 \]

May crack the steel from high internal pressure. May cause loss of strength as C disappears.