



## DATA SHEET No. 2 Titanium and Hydrogen

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In certain environments, under specific conditions, titanium can absorb hydrogen. This does not necessarily cause a problem or limit service life. Hydrogen uptake can normally be avoided by the proper design of equipment and control of operating conditions.

In most offshore and sea water applications, neither the service temperature, nor the potential from correctly selected sacrificial anodes, or properly regulated impressed potential cathodic protection systems are within the range for the absorption or diffusion of hydrogen into titanium. Cases of through section hydride formation, leading to embrittlement and cracking or failure under stress in service are very rare.

### **In sea water or sour service, problems may be caused by:**

- coupling of titanium to a less corrosion resistant metal
- cathodic protection systems producing negative potentials  $< -0.85\text{v SCE}$ .
- tensile loadings or residual stress if hydrogen uptake is occurring
- pH less than 3 or greater than 12 will increase the risk of uptake
- higher temperatures which increases corrosion at the anode and hydrogen activity at the cathode

Titanium will usually be the cathode in a mixed metal system, hydrogen produced at the cathode is available to be absorbed. Hydrogen sulphide will accelerate the uptake of hydrogen in the presence of a cathodic potential.

### **Surface condition is an important control**

- the normal oxide film is a barrier to hydrogen diffusion
- carbonate films formed by cathodic charging in sea water protect against hydrogen absorption
- iron embedded or smeared on the titanium surface may accelerate hydrogen uptake only in certain chemical plant at high temperatures.
- rust and rust stains on the surface of titanium pose no problem.

### **Preventative strategies**

- electrical isolation of titanium in mixed metal structures
- coating of titanium to reduce its effect as a cathode, and/or restrict the area of titanium likely to be affected
- choice of sacrificial anodes to limit the cathode potential, aluminium and magnesium anodes cannot be recommended, their potentials are too negative

### **Solubility and diffusion of hydrogen**

- solubility in pure titanium and alpha beta alloys is limited, (50 - 300 ppm). Once the limit is passed hydride is precipitated.
- solubility in beta alloys is typically 4000 ppm, with up to 2000 ppm having no effect whatsoever on strength or ductility.

- at temperatures below 80°C diffusion is slow and hydrogen tends to be restricted to surface layers of metal.
- precipitation limited to the surface layers is unlikely to be harmful.
- the uptake of hydrogen caused by dissolution of titanium in reducing acids or other corrosive environments for which it is not suitable is of secondary concern.

#### FOR FURTHER INFORMATION CONTACT

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