Hydrogen leak testing does not lead to hydrogen embrittlement.

The Hydrogen Method has been used for leak detection since 1985 in various manufacturing industries such as refrigeration, automotive and medical devices. The aerospace industry is a relatively new user of the hydrogen method and has, due to the very high level safety standards, needed to raise the question whether hydrogen leak testing can cause metal embrittlement. This document explains why hydrogen as tracer gas for leak detection on aircraft fuel systems does not result in metal embrittlement.

For the interested reader a more scientific review on metal embrittlement and why it is not relevant to leak testing with diluted hydrogen gas, is available from reach.sweden@inficon.com.

A further study on the subject issued by the Swedish Institute for Corrosion and Metals Research Swerea/Kimab, Sweden, can also be ordered from reach.sweden@inficon.com.

Yes, hydrogen embrittlement is a real, physical phenomenon and can be a serious problem for high tensile steel, titanium and aluminium alloys if the concentration of atomic hydrogen in the metal exceeds a critical level.
No, hydrogen embrittlement is not caused by normal leak testing procedures with 5% hydrogen/ nitrogen gas mixtures on aircraft fuel systems.

Why metal embrittlement is not an issue for hydrogen leak testing on aircrafts.

The ductility[1)] of a metal can be reduced if the metal contains hydrogen atoms above a critical level. This requires that ingress of free hydrogen atoms has been allowed during manufacturing or processing of the metal material and that these atoms have been trapped inside the solid metal. The hydrogen atoms normally comes from heated moisture and hydrocarbons or acid solutions.

1) **Ductility** is a mechanical property used to describe the extent to which materials can be deformed without fracture.

INFICON AB

Box 76, SE-581 02 Linköping, Sweden
Tel: +46 (0)13 35 59 00, Fax: +46 (0)13 35 59 01
www.inficon.com E-mail: reach.sweden@inficon.com

Hydrogen gas is a relatively stable compound and does not easily decompose into free hydrogen atoms at normal temperatures. Even if it would to any extent, these atoms would not easily diffuse into a solid metal, especially not aluminum, stainless steel and titanium all of which have a protective surface oxide layer which is an effective diffusion barrier.

Furthermore, hydrogen embrittlement is not a permanent condition. If hydrogen atoms are allowed to diffuse out again the metal regains its full strength.

Hence, hydrogen embrittlement requires that hydrogen atoms, above a critical concentration, are present in the metal *while* it is exposed to high loads. If a solid metal is exposed to hydrogen gas, embrittlement would require a reaction whereby free hydrogen atoms would be formed on the surface and that those atoms have had time to penetrate through the surface oxide and further into the metal to reach the critical concentration and not have time to diffuse out again before the metal is exposed to high loads. This cannot happen during leak detection, a fact proven by third party laboratory experiments as well as years of experience of using hydrogen for leak testing in a number of manufacturing industries.

Conclusion

There are a number of reasons why leak detection with 5% hydrogen/nitrogen gas does not cause any damage to metals:

- There is nothing in the testing environment that would cause the gas to decompose into free hydrogen atoms.

- Even if this would happen, there are natural barriers to prevent the atoms from entering the metal alloys (and sometimes also anodized surface layers, primers and paints)

- Even if this could happen in principle, the time of exposure and the low pressure of Hydrogen is, by far, too insignificant to have any effect on the strength of the metal.

Linköping, Sweden, May 2008

INFICON AB