

Welded Gaseous Storage Vessels and Hydrogen Compatibility

1. Introduction

This Technical Bulletin reflects Appendix 5, which was removed from EIGA Doc 15/21 [1]. The recommendations are kept concerning the suitability of welded gaseous storage for hydrogen service and provides guidelines for minimising the effects of embrittlement when designing new welded storage vessels and gives recommendations for assessing the safety of existing storage vessels, when the design pressure is greater than 25 bar.

The two most important factors in ambient temperature hydrogen embrittlement are the purity of the hydrogen, and to a lesser extent the hydrogen pressure.

In determining a critical value for oxygen impurity, the literature is somewhat variable. However, generally the hydrogen embrittlement effect is maximised when the oxygen impurity is less than 10 ppm/V but decreases with increasing impurity to the extent that oxygen levels above 200/300 ppm/V completely inhibit the hydrogen embrittlement effect. As with impurity, opinions vary as to what is a critical pressure. Generally, for carbon steels below 10 bar, the effect of hydrogen in causing ambient temperature embrittlement is minimal, while hydrogen pressures above 25 bar have a progressively greater effect.

There are three possible mechanisms that could be responsible for the initiation and propagation of a defect, causing welded hydrogen vessels to fail:

- a. The presence of critical surface defects resulting from manufacture or previous service. Such defects may then be subjected to hydrogen assisted crack propagation under the normal influence of the vessel filling cycles.
- b. The initiation and propagation of the hydrogen assisted fatigue cracks due to very high additional local stresses.
- c. The use of a material and/or weld deposit that is highly susceptible to hydrogen embrittlement.

2. Guidelines for the design of hydrogen storage vessels

Vessels for the storage of hydrogen shall be designed, fabricated and inspected in accordance with a recognised pressure vessel code and the following requirements:

2.1 Materials

- 2.1.1 The actual yield strength of the material shall be no greater than 420 MPa.
- 2.1.2 The actual tensile strength of the material, shall be no greater than 630 MPa.
- 2.1.3 The material shall be in the normalised condition.

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- 2.1.4 The material shall have specified values for toughness at -20°C. according to the pressure vessel code.
- 2.1.5 The carbon equivalent shall conform to the following requirement

$$Ceq = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{Ni + Cu}{15} < 0.45$$

2.2 Design and Construction

- 2.2.1 A fatigue analysis based upon the design cyclic duty should be performed. The analysis should include the effects of hydrogen which are reported in the literature.
- 2.2.2 Local stress raisers shall be minimised by:
- Appropriate design and positioning of nozzles, manholes, supports and attachments and the selection of suitable weld details. Penetration welds are preferred.
 - Ensuring welds have uniform profiles that are well blended into the surface of the parent plate and free of undercut or over reinforcement.
 - Avoiding gouges, scrapes, grinding marks and weld splatter during manufacture. The maximum depth of the defect shall not exceed 5% of the wall thickness.
 - Employing plate rolling techniques that minimise peaking. (Peaking is a deviation from the truly circular shape that occurs at welds due to an inability to roll to the plate edge. The allowable peaking depends on the diameter of the vessel, see Fig. 1 and 2).

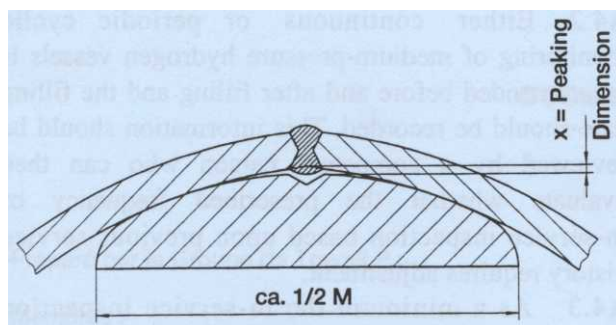


Figure 1 – Internal template

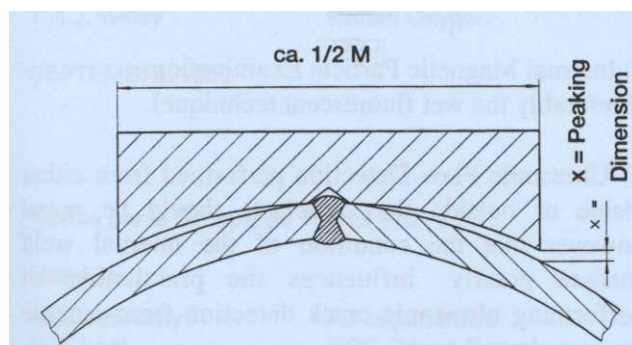


Figure 2 – External template

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