STORHY FINAL EVENT
HYDROGEN STORAGE SYSTEMS FOR AUTOMOTIVE APPLICATION
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STORHY

Probabilistic Assessment of Containments: An Alternative Approval Approach

Objectives

- Failure of technology cannot be entirely avoided. Therefore, critical incidents have to be prevented to the extent of a generally accepted level of frequency and consequence as safety target.
- Such safety targets are the basis of every approval requirement.
- Based on decades of experience, it is still common to assess the safety of containments by proving safety margins concerning rupture under static load.
- The requirements for cyclic fatigue testing for composite cylinders are similarly based on demonstration of load cycles without failure. The basic concept of deterministic safety margins remains.
- However, experimental data show that safety margins do not always correspond to the scattering of strength. The reasons are different failure processes, material- and manufacturing-specific scattering and changing residual stress levels. StorHy results outline that current approval requirements constitute the main hurdle for a substantial improvement of containment design and individual safety properties with respect to relevant safety goals.

Assessment Results

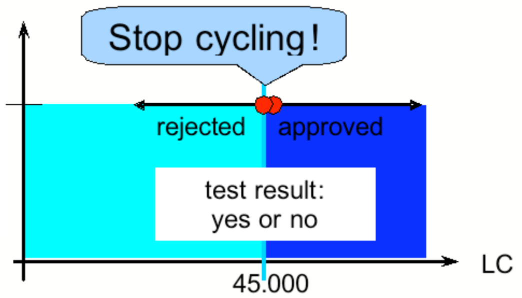
A safety goal can be described by a failure consequence and its accepted frequency (e. g. one sudden rupture per year).

- But how to assess this by asking for general values, such as minimum burst pressure or minimum load cycles (see right)?
- The only solution is to ask for certain reliabilities against relevant failure modes at the operating point (see right below). This would allow maximum freedom for substantial design improvements and cost reduction of safe hydrogen storage systems.

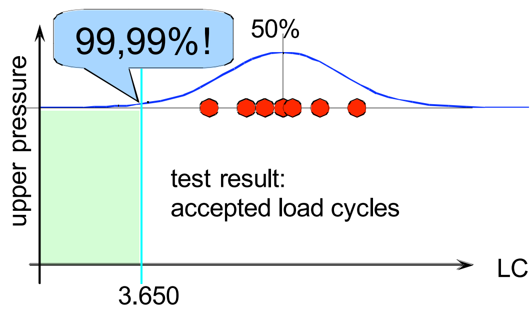
An example for the limits of the conventional approach can be explained as follows:

Under cyclic loads different materials used for liner or composite reinforcement of pressure containments show different specific ranges of load cycle distribution: e. g. as a side effect of their low susceptibility to cycling, a wrapping of carbon fibre reinforced plastic (CFRP) shows higher statistical scattering of cycle fatigue than a metal liner. Consequently, to achieve the same safety goals, it is necessary to require different safety margins for different materials. This means that a Type IV cylinder made from CFRP has (and is able) to demonstrate a higher minimum number of cycles in order to assure a certain safety level than a Type III cylinder, the most critical element (first failure) of which is the metal liner with a naturally lower scatter of fatigue strength.

e. g. Conventional Fatigue Testing



e. g. Probabilistic Fatigue Testing



Future Perspectives

- Quantitative risk based models and probabilistic system optimization procedures show new potentials of weight reduction and safety increase and pave the way for a regulation which can flexibly follow the current-state-of-the-art.
- StorHy SP SAR results could support reviewing regulations, codes and standards to combine the quantitative probability assessment with a comprehensive description of the protection purpose of regulations.

Partners	BAM; Ministerio de Defensa; INTA – Instituto Nacional de Técnica Aeroespacial
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