Project No.: 502667
Project acronym: STORHY
Project title: Hydrogen Storage Systems for Automotive Application
SP: SAR - Safety Assessment and Regulations

The Most Important Safety-Related Result within StorHy: Need for a Probabilistic Approach

Recent R&D activities within the EU-funded FP6 project StorHy have shown that the current approach to regulations and standards (R&S) concerning hydrogen storage systems for automotive applications is not flexible enough to enable designing of lightweight and highly safe storage structures.

Lightweight structures not only help reduce the total weight of vehicles, they also require considerably less material, which entails a significant reduction of costs and increase in energy efficiency.

However, the current R&S prevent a breakthrough in achieving the general technical requirements for automotive application. The general safety level of onboard storage systems is currently validated by a deterministic system of defined test procedures described e. g in the draft paper UN WP 29 GRPE rev. 12b concerning hydrogen. These tests aim to demonstrate isolated target values only, which merely provide the information for a decision of 'Passed' or 'Not passed'. Some of this target values are based on single fixed safety factors as e.g. the burst ratio or an excessive number of cycles.

This approval procedure constitutes one of the main hurdles to achieving the global goals of lightweight, cost-competitive and safe onboard hydrogen storage systems. This is also valid for hydrogen distribution in trailer vehicles or in Multiple Element Gas Containers (MEGC) as well as for CNG vehicle applications.

One promising way to overcome this hurdle and raise the design flexibility is a safety concept called "Probabilistic Approach" (PA), which is comparable to other already applied procedures for safety assessment of complex technical installations with significant risk potential for public safety, e.g. the risk assessment of nuclear power stations or the reliability assessment of airplanes. There is an essential difference between the new PA and assessment procedures already in use. The PA addresses future high volume production, such as fuel gas storage systems, and will use statistical data resulting from destructive tests performed during the design type assessment to build up a specific probabilistic data base.

In its final stage, the Probabilistic Approach will focus on evaluating the general failure probability of the whole system. This allows working without any single fixed safety factors used by the current deterministic approach while maintaining or even increasing the safety level. In the beginning, however, it will be necessary to initiate the PA by focusing on validating isolated probabilistic requirements.

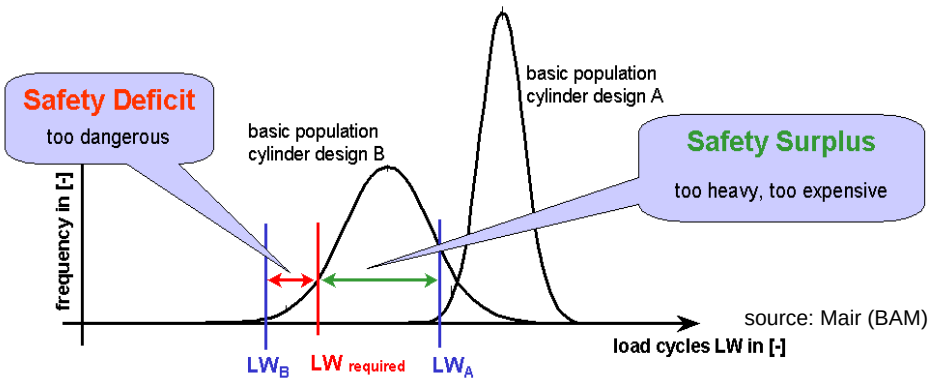

Fig. 1: Distribution of failure probability in relation to number of load cycles

Fig. 1 shows the distribution of failure probability in relation to the number of load cycles up to failure for (unknown) basic populations of two different designs. The two cylinder designs have different properties of resistance to fatigue failure (defined as lifetime LW_A and LW_B at a reliability level of e. g. 99,9 % of resistance to leakage) or even different failure probabilities at required cycling numbers ($LW_{required}$). This circumstance is not taken into account by current approval regulations. For the transport of dangerous goods and even for the onboard storage of gases, only a certain fixed number of load cycles has to be validated (red line). A Probabilistic Approach would require a higher number of test samples for each design type. Thus it would be possible to estimate the frequency distribution of the basic population and to assess safe and unsafe areas of operation, which would allow defining where additional measures are necessary and where material can be reduced (green arrow: safe, red arrow: unsafe; depending on given probability).

The Federal Institute for Material Research and Testing (BAM, Germany), the subproject leader for safety-related issues (SP SAR) within StorHy, is driving the drafting phase of the PA to build an alternative process in future R&S for approving automotive fuel gas storage systems. Replacing the current deterministic requirements, e.g. stress ratios or a fixed number of life cycles, by a Probabilistic Approach will provide more quantifiable safety along with a better utilization of material. Therefore, the required research activities on probabilistic safety assessment should be implemented within the upcoming FP7. These activities should include test procedures as well as validation of the current safety level by testing storage cylinders, which are presently available on the market, in a quantitative manner. Thus it will be possible to elaborate useful requirements within a regime of test procedures addressing the Probabilistic Approach before 2010 as a first step towards a comprehensive risk-based Probabilistic Approach.