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Societal risk and safety factors for pressure vessels for road transport of hydrogen

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Hydrogen is a popular alternative for current energy carriers. Compressed gas pressure vessels are the storage systems closest to the mass commercialization of hydrogen in vehicles. The safety factors for the pressure vessel design are defined in current design standards, indirectly determining the laminate thickness, weight and cost of the pressure vessels. The deterministic, fixed valued safety factors currently used are perceived by the industry as too high. A probabilistic approach was employed to calculate new safety factors under short and long-term loading conditions by extending the methods given in the DNV-OS-C501 offshore standard.

The calculation of safety factors requires the estimation of an acceptable probability of failure for hydrogen pressure vessels. The acceptable probability of failure is determined by the public acceptance of high-consequence structural failures. The evaluation of public acceptance requires an analysis of possible accidents with hydrogen pressure vessels in populated urban environments. This topic is sensitive, as one large scale accident can affect the public opinion and consequently become very costly for the industry. Surprisingly, literature overview revealed only a few studies about the societal risk of hydrogen pressure vessel failure in trucks and road vehicles.

In the current work, it is shown how safety factors for composite pressure vessels are directly dependent on the defined acceptable probability of failure of this system component. On the system level, a numerical modelling approach is presented showing how to evaluate the societal risk created by vehicles with on-board pressure vessels filled with gaseous hydrogen. Constantly incoming new information about accident consequences and their probabilities is shown to update the estimates for the societal risk FN curve.

Keywords: Hydrogen pressure vessel; safety factors; probabilistic approach; societal risk modelling