TOOL CHAIN FOR SAFETY EVALUATION OF HYDROGEN APPLICATIONS

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Introduction

The identification of hazard potentials and its rapid and accurate validation is of crucial importance for safe hydrogen applications. To prevent incidences and derive sufficient and appropriate safety measures, targeting and fast evaluation is necessary during engineering phase and certification processes. Experience in recent years has also shown that the authorities or notified bodies are increasingly demanding an in-depth safety assessment. National standards must be taken into account as well as industry or company-specific requirements, such as those in refineries. Location-specific conditions have to be considered in order to develop a suitable safety concept. This publication presents a methodological toolkit that allows direct and indirect hazard potentials to be determined. The practice-orientated and implementation-oriented approach makes it possible to answer safety-relevant questions accurately. This enables safe H_2 applications and accelerates approval processes and commissioning.

Method

The tool chain enables the determination of direct hazards such as explosion zones and blast waves (see Figure 1 and Figure 2) as well as indirect hazards such as flying debris. As a direct result, the consequences of damage to people and systems are derived in order to develop suitable safety measures on this basis. Since mobile hydrogen applications are also being used more and more, H_2 propagation at the vent and the spread of explosive atmospheres must also be accurately assessed (see Figure 3). This allows safety distances to be defined as a function of the structural and meteorological boundaries.

The methodological approach combines classic hazard and risk analyses with thermodynamic and CFD-supported simulation methods. The functional principles of hydrogen technologies as well as their operation modes are integrally considered.

The toolchain provides the following individual steps:

1) Analysis of the technical structure, its operating states as well as environmental conditions.
2) Definition of different (worst-case) scenarios that could potentially cause damage to people and the system if they occur.
3) Derivation of technical boundary conditions such as pressure levels, H_2 release potentials, stationary conditions in operation etc.
4) CFD simulation of the relevant safety-relevant damage event
5) In post-processing, relevant transient and stationary measures are evaluated:
    a. H_2 spread and formation of explosive mixtures
    b. Blast wave propagation and possible reflections (risk of self ignition)
    c. Temperature of hydrogen (risk of self ignition)
    d. H_2 mass of the ignitable mixture
6) Assessment of the explosion effect and the damage potential using TNT equivalent [1]
    a. Impact of the pressure wave on people's health
    b. Evaluation of protective measures such as explosion flaps, swirl plates, etc.
    c. Evaluation of debris flight
7) Derivation of appropriate technical and operative safety measures

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Results

The results of the procedure allow well-founded statements to be made about:

- Assessment of standard safety measures such as stationary ventilation and dilution
- Effectiveness of activated safety measures such as explosion ventilation and explosion flaps
- Assessment of the explosion effect and damage caused by detonation and blast wave
- Derivation of structural, operational and procedural safety measures as well as limitation of safety distances

In the publication and the presentation, results are illustrated using exemplary references.

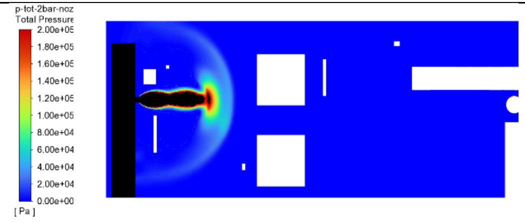

Figure 1: Blast Wave Propagation in electrolyser container

Figure 2: H2-Dispersion within electrolyser after 0,5 seconds

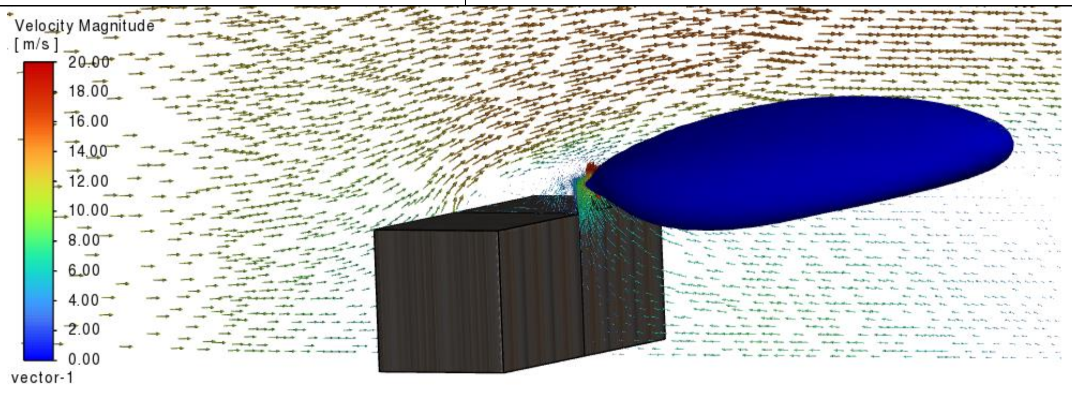

Figure 3: Hydrogen dispersion in atmosphere and flameable gas cloud propagation (lower explosion limit marked blue)

References

[1] US Departmend of defense, “Structures to resist the effect of accidental explosions”, UFC 3-340-02, 2005