

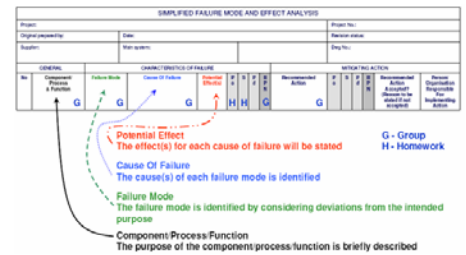
Cryogenic Storage Safety Analyses

Objectives

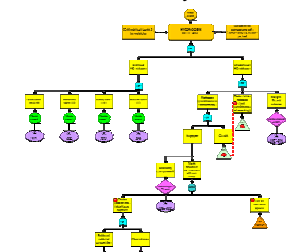
- ❖ A safe liquid hydrogen storage tank
- ❖ Consideration of component failures in the tank system and hazards resulting from in-service environments
- ❖ Identification and prioritisation of technical risks, and the development of mitigating measures

Achievements

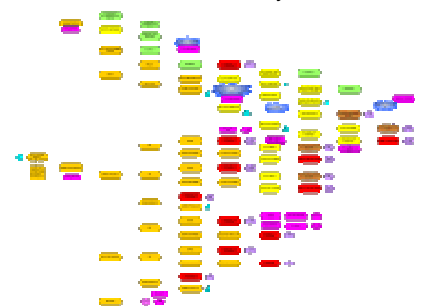
- ❖ **Simplified Failure Mode and Effects Analysis (FMEA)**
 - Identification of failures resulting in unintentional hydrogen releases with the potential for combustion, cryogenic or physical energy (e.g. rupture) hazards
 - In-service environments considered included: Normal operation, refilling, maintenance, parking, traffic accidents, misuse, etc.
 - More than 300 potential failures were identified, of which approx. 130 were considered serious. Mitigating measures were identified for all but 2 of those failures which will be the focus of future work.
- ❖ **Fault Tree Analysis (FTA)**
 - A FTA was undertaken to identify combinations of occurrences that could result in a "hydrogen release". The work was focussed on ruptures, i.e. instantaneous, high mass flow with full tank quantity.
 - The FTA included up to 16 levels of branches and more than 400 events. Results will be used to identify mitigating measures in future projects.
- ❖ **Event Tree Analysis (ETA)**
 - An ETA identified the effects of fire on the tank system.
 - The work identified a number of potential mitigating measures that will be addressed in future projects.
- ❖ **Gap Analysis**
 - A gap analysis cross-checked the final design with appropriate regulations and standards to control compliance with requirements.
 - Issues that may be feedback to the organisations developing regulations and standards were identified.



FMEA Layout



Fault Tree Analysis



Event Tree Analysis

Future Perspectives

- ❖ Long term reliability, manufacturing and recycling have to be addressed.
- ❖ Remaining open issues of the different analyses have to be considered in follow-up projects.

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