30.03.2023

Report out BEV and HFCV Users' group

Introduction and scope

The work of the informal working group for battery electric and hydrogen fuel cells vehicles (IWG) was split into various sub-groups.

The sub-group "Users" has been set up to get input and feedback from parties which make use of these vehicles, that comprises the ADR roles consignors, consignees, fillers, carriers and unloaders. In practice the group includes chemical/oil/gas industry and carrier associations, and a number of country delegates.

The focus of the group is to identify at an early-stage situations and scenarios which can be concerning for those parties, and to discuss how to ensure that those concerns are dealt with in the next versions of ADR, which will contain provision for the construction and use of BEV and HFCV.

Scope of the work is all the activities covered in ADR, that is consigning DG to carriers, filling DG into tanks, transporting DG from the loading to the unloading point. These activities also include intermediate stops, battery charging/H2 filling, incident management.

Participants

The working group met 14 times (3 times face-to-face, 11 times virtually). 4 of these meetings were also attended by some of the members of the "Manufacturers" sub-group.

Below is the list of the participants of the users' subgroup.

Name	**Association/Dept**
Pinna, Dario	CEFIC (NGO)
Naessens, Joost	CEFIC (NGO)
de Putter, Kees	RDW (NL) (Gov.)
Pelletier, Karine	OICA (NGO)
Witoszynskyj, Andreas	EN2X(NGO)
Laerda, Arne	DSB (NO) (Gov.)
Bogaert, Michael	Vervaeke (Industry transport)
Etienne Cools	SPRB (BE) (Gov.)
Ionescu, Mircea	EC (EU) (Gov.)
Kulkarni, Narasinha	Shell (Industry)
Wood, Jon	DFT (UK) (Gov.)
Schuetz, Christoph	EIGA (NGO)

Steiner, Dagmar	N2X (NGO)
Aldo Celasco	International Road Union Road Transport Association (IRU) (NGO)

Methodology

The sub-group decided to perform a risk analysis to assess possible scenario that can lead to adverse consequences.

The agreed way of identifying risks in using BEV and HFCV is the bow-tie analysis, applied to the below locations:

- Loading sites (including both big petrochemical sites, oil refineries and small sites)
- A recharge/refill station
- During transit (including parking)
- Unloading sites (including both big petrochemical sites, oil refineries, small sites and petrol stations)

The team first identified the main hazards present in using BEV/HFCV in these situations and activities.

A hazard is an agent that has the potential to cause harm to people, damage to assets, business loss and impact on the environment or reputation. A hazard is by itself not negative, but if not “handled” with care it can lead to a dangerous consequence. Examples of hazards includes flammable substances, moving vehicles, rotating machinery, toxic substances, and personnel at height.

This methodology helps to identify and assess barriers required to effectively manage these hazards.

A hazard can be “released” in a dangerous way: this release is caused “top event”.

The couple hazard/top event identified are the following:

1. Battery chemical energy/Battery runaway
2. High voltage electricity/High energy spark released
3. Temperature/High temperature
4. High pressure hydrogen/Loss of containment
5. Dangerous goods/Spill on battery
6. (Liquid hydrogen/Loss of containment) – not discussed yet

The top event can occur due to different “initiating events” or “threats” and can lead to different “consequences”.

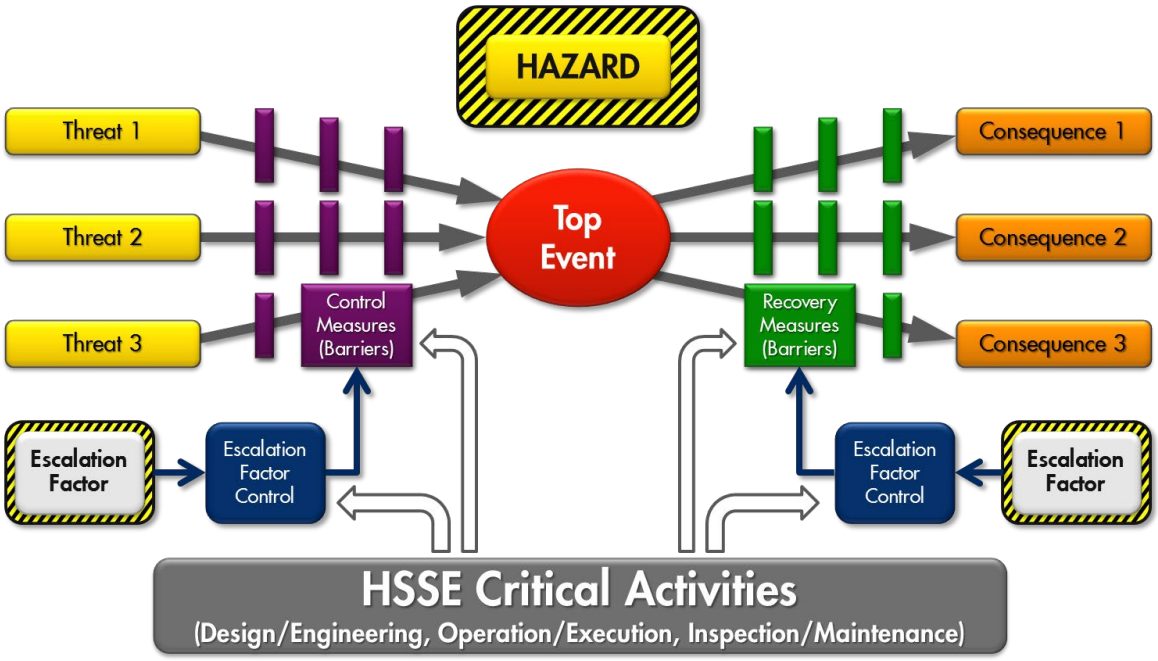
The bow tie is a graphical representation of these “threat-to-consequence” scenarios for a specific couple of hazard/top event, and of the barriers which are in place to prevent the top event to take place (left side of the bow tie), or to lead to the consequence (right side of the bow tie).

A barrier, in order to be valid, needs to be effective, independent, and auditable.

“Effective” means that if the barrier works as designed, then the treat doesn’t lead to the top event.

"Independent" means that its working doesn't rely on (parts of) other barriers or on other initiating events.

"Auditable" means that it is designed in a way that one can check (audit) its correct working at any time.



The subgroup then drew 5 bow ties, with the relevant threats/consequences/barriers and qualitatively[1] discussed which scenario seems to have too weak (or no) barriers.

In order to make this assessment the group must judge on the likelihood of the scenario and on the "strength" of the barrier in place.

The sub-group first made this analysis with its participants, and later on discussed it with the manufacturers sub-group in order to ensure that no missing items nor misunderstanding on the technicalities of the barriers were present.

Results

The scenarios for which the risk is considered as not enough managed after this risk analyses are:

1. Release of a spark in an ATEX zone, leading to ignition of a possible vapor cloud in a loading/unloading area
2. Mechanical abuse of battery leading to battery runaway
3. External fire leading to battery runaway
4. Battery runaway leading to exposure of driver to toxic fumes
5. Battery runaway leading to BLEVE of a tank containing flammable gas

[1] Here qualitatively means "not quantitatively", so the remaining risk for a scenario is not calculated considering the frequency of the initiating event and the probability of failure on demand of the barriers, but just looking at those concepts in a "qualitative" manner

6. Collision and damage of shutoff valves, leading to H2 leak

For the above scenarios extra, mitigating barriers must be developed:

1. Add a barrier to prevent ignition of a flammable gas cloud, to be technically developed. Example (not limiting) is having the possibility of de-energizing the HV system and that permanently energized system is EX proof, as already in ADR 9.2.
2. To be technically developed. Difficulty here is that this has an “ADR consequence” but it should be captured in R100.
3. To be formally developed.
4. To be technically developed. Difficulty here is that this has an “ADR consequence” but it should be captured in R100.
5. Ensure awareness of risks related to use of "alternative fueled" vehicles to be taken into the ADR driver training (8.2.2.3.2)
6. To be technically developed

Below are other items which had been brought to the table in various discussions, but not formally included in the bow-ties, but which are worth mentioning for possible ADR amendment:

- Require specific trainings for responsible roles (driver, filler, etc.)
- Develop specific checklists for BEV/HFCV
- Ensure vehicles are labeled
- Certificate of approval mentioning EV or H2
- Prevent a flammable gas from entering the battery pack

Conclusions and way forward

The sub-group users wishes to report its conclusion to the IWG, for further considerations on how to reduce some of the risks involved, by amending ADR or other UN regulations.

The report can be considered as an input for other subgroups and their proposals for ADR amendments.

In the future the users’ sub-group can meet again to

1. Develop a bow-tie for liquid hydrogen
2. Develop a bow-tie for use hydrogen in internal combustion engines
3. Verify if the proposals of the IWG to the WP15 are enough to reduce the identified risks to an acceptable level

Appendix – Highlighted notes from meeting reports

13.09.2021 (1st meeting)

- The purpose of this core group is to identify the concerns and questions by the user of electrified vehicles. Answers should be found in the core group or could be answered by other core groups such as the one for vehicle manufacturers.
- It was said that also non-technical issues should be addressed such as additional items for driver training
- Risk analysis

Item	Hazard	Comments	Reaction - Mitigation
Battery pack	Chemical reaction with load	In some cases, the battery pack may be compromised by corrosive substances.	A drip free cover would be sufficient.

17.01.2022 (4th meeting)

- The team concluded that there is little added value in spending time understanding the details of the standards placed at the left side of the bow tie, as long as we know that they are there, and that they are valid barriers (i.e., they are effective in preventing the top event or the consequence to occur).

02.02.2022 (5th meeting)

- In general, it is believed that drivers should be trained on the use of BEV, also in their ADR training, but this is formally already covered by ADR 8.2.2.3.3.b, which should not be modified:
- So, the question in our specific cases of course is how the design is enforced and if the design is good enough to prevent the top event.

16.02.2022 (6th meeting)

- Specificality about the threat “Defect connector in recharging equipment”: we discussed the possibility of proposing a barrier “training to drivers not to use damaged connectors”, but that is not relevant to ADR transport only, so in the future this will be removed.

31.10.2022 (11th meeting)

- The scenarios for which the risk is considered as qualitatively non enough managed at present are:
  7. Release of a spark in an ATEX zone, leading to ignition of a possible vapor cloud in a loading/unloading area
  8. Mechanical abuse of battery leading to battery runaway
  9. Debris in battery leading to battery runaway
  10. External fire leading to battery runaway
  11. Battery runaway leading to exposure of driver to toxic fumes
  12. Battery runaway leading to BLEVE of a tank containing flammable gas

  For the above scenarios extra, mitigating barriers must be developed:

1. Add a barrier to prevent ignition of a flammable gas cloud, to be technically developed. Example (not limiting) is having the possibility of de-energizing the HV system and that permanently energized system is EX proof, as already in ADR 9.2
2. To be technically developed. Difficulty here is that this has an “ADR consequence” but it should be captured in R100.
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4. To be technically developed. Difficulty here is that this has an “ADR consequence” but it should be captured in R100.
5. Ensure awareness of risks related to use of "alternative fueled" vehicles to be taken into the ADR driver training (8.2.2.3.2)
6. To be technically developed

Below other possibilities which had been proposed in the previous meeting have not been discussed but are still worth considering.

- Trainings of responsible roles (driver, filler, etc.) as possible barriers
- Checklists as possible barriers
- Labels for H2, for BEV are already required (see reg. 134 and ISO 17840). (**Post meeting comment from IVECO**: The propulsion label accordingly to ISO 17840 should be mandatory at least for ADR vehicle)
- Certificate of approval mentioning EV or H2
- Possibility to prevent the gas from entering the battery pack, after the spark took place (right side of the bow tie) (**Post meeting comment from IVECO**: the possibility to prevent the gas entering should be analyzed. When the current flows in the battery the pressure is slight higher than the ambient pressure)

28.11.2022 (12th meeting)

- Quality management system is company decisions and strategies. Our working group may speak about battery performances, aging, durability, but not quality. Multiple regulations, directives, standards list specific performances criteria or technical demands. ADR shall not consider defining criteria for battery aging/life but use the adequate existing text.
- IEC 62660 specifies the test procedures to obtain the essential characteristics of lithium-ion cells for vehicle propulsion applications regarding capacity, power density, energy density, storage life and cycle life. It's followed by OEMs on a voluntary basis and ensure the performances but not the quality.
- It was decided to adopt a stepwise approach: first concentrate on fuel cells vehicles and only later – if time allows - check for differences with combustion H2 vehicles.
- New threat added “Collision and damage of shutoff valves”, no barriers have been identified.
- Some discussion rose on the controlled release of H2 by a relief valve. This is not to be considered an LOPC (loss of primary containment, i.e., an uncontrolled release), but must still be considered in the design that the release of the RV should be at safe location.

Open items

- Any risk related to charging in particular situations (i.e., during filling tanks or in ATEX zones)?