HyCoRA – Hydrogen Contaminant Risk Assessment Grant agreement no: 621223

Deliverable 5.3 Summary of OEM workshop 1

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Summary

The workshop discussions during the presentations and for OEM guidance to the HyCoRA project were as follows:

- All OEM consider the risk model approach of HyCoRA project principally correct and supply chain specific QA requirements were supported; however, it was advised to keep the model simple, as quantitative data for the model may be difficult to achieve.
- Automotive OEM consider **hydrogen quality** - currently monitored by pass/fail criteria especially in large hydrogen production plants frequently (continuously) - and **price** as **key parameters** for the **FCEV commercialisation**; hydrogen quality can be monitored by monitoring PSA process parameters but failure in process parameter monitoring will cause quality problems. The only possibility for H2 contamination in retail hydrogen is a failure in quality control of central production at the same time, when PSA purification is failing
- Consequently, risk mitigation can be done by improving process monitoring so that measurement sensors with no common failure mode are used. It indicates adding **a second quality monitoring instrument** could be **efficient risk mitigations**, assuming that there are no common failure modes. Data from PSA model can be difficult to validate with the real process; however, in risk model PSA data could be used initially without validation as quantitative data from hydrogen producers can be available in the future, but this is not assured. Data exists only for limited number of species in PSA models. The continuous monitoring of **canary species** was considered as one way to have **inexpensive risk mitigation** methods. It was also considered possible that continuous monitoring may not have the same requirements as when doing full analysis for ISO 14687:2-2012 species.
- Monetary value for the loss of FCEV reputation will be difficult to estimate.
- **Particulates** were considered as a **major issue**, since large (over 0.005 mm) particles can be **detrimental** for the **high pressure components** of on-board hydrogen storage in FCEV. Also, **halogenates** contamination due to supply chain were considered **difficult to measure** but should be quantified; it might be minimised by improving operation and maintenance of the HRS requiring co-operation with HRS manufacturers, in addition to hydrogen suppliers (tube trailers). When hydrogen is by-product from industry, a real risk of chloride additions exists; otherwise, the risk is rather small from the production (PSA purification, water electrolysis).
- In the current standard (ISO 14687:2-2012) formic acid and formaldehyde were considered very problematic to measure with the levels in the standard. As these are also the most probably contaminants having too low limits, it was advised that formic acid and formaldehyde should be further studied for providing data for a possible revision of ISO 14687:2-2012.

Finally, it was advised to keep the risk model simple and to include formic acid and formaldehyde as reversible contaminants, as these are complicated for the analysis and the experimental effort for the revision of the limits in ISO 14687-2:2012 could be reasonable.

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Contents

1. Workshop Agenda

30 September 2014		Speaker
08:30-09:00	Arrival	
09:00-09:10	Welcome and opening remarks on hydrogen fuel quality workshop	*Georgios Tsotridis, EC DG JRC-IET*
09:10-09:50	HyCoRA project objectives, scope and first results	*Jari Ihonen, VTT*
09.50-10:30	Risk assessment in HyCoRA project – qualitative model	*Risto Tuominen, VTT*
10:30-11:00	Break	
11.00-11:30	Hydrogen fuel purification – different technologies and quality failure risks issues	*Marco Succi, SAES Pure Gas*
11:30-12:00	OEM Needs on hydrogen fuel quality assurance – ideas and views	*J Roussel, Toyota Europe*
12:00-12:30	Pre-concentration strategies for hydrogen fuel quality control	Shabbir Ahmed, *US DoE-ANL*
12:30-13:00	Performing hydrogen fuel quality control - sampling strategies and challenges	*Anders Ødegård, SINTEF*
13:00-14:00	Lunch	
14:00-14:30	Analytical methods for quality control - potentials for cost reduction	*Arul Murugan, NPL*
14:30-15:00	PEFC testing procedures assessing consequences of hydrogen fuel quality assurance	*Jari Ihonen, VTT*
15:00-15:30	Risk assessment in HyCoRA project – need of data for the quantitative model	*Risto Tuominen, VTT*
15:30-16:00	Break	
16:00-17.00	OEM panel discussion concerning the focus of HyCoRA project	*All*
17:00-17.15	Workshop conclusions & closing remarks	*Georgios Tsotridis, EC DG JRC-IET*
17:15	End of workshop	

2. Workshop Participants

Participant name	Participant organisation
Gerhard Gissibl	BMW
Sebastian Mock	Daimler
Norbert Klein	Hyundai Europe
Julien Roussel	Toyota
Marco Succi	SAES
Arul Murugan	NPL
David Carteau	Air Liquide
Alice Elliot	Shell
Shabbir Ahmed	ANL
Ole Kjos	SINTEF
Thor Aarhaug	SINTEF
Jari Ihonen	VTT
Risto Tuominen	VTT
Per Ekdunge	Powercell
Victoria Brewster	Protea
Pierre-André Jacques	CEA
Georgios Tsotridis	JRC

3. Summary of presentations

HyCoRA project objectives, scope and first results (Jari Ihonen, VTT)

- HyCoRA project objectives and scope were introduced with work distribution between partners.
- First fuel cell results with CO as contaminant from WP1 were introduced.

Risk assessment in HyCoRA project – qualitative model (Risto Tuominen, VTT)

- Introduction to qualitative model for risk assessment in HyCoRa project including presenting modelling approach
- Tentative ID model for FCEV performance degradation due to CO contamination in fuel

Hydrogen fuel purification – different technologies and quality failure risks issues (Marco Succi, SAES Pure Gas)

- Existing technologies for H2 purification are already capable of complying with the target set by ISO14687 for FC applications
- Gas purification must be integrated into the H2 supply chain

- Dedicated purifiers could be designed to seamlessly integrate with the H2 distribution chain
- Gas purifiers can easily provide consistent H2 purity at the low levels needed for fuel cell applications

OEM Needs on hydrogen fuel quality assurance – ideas and views (automotive OEMs)

- Worldwide harmonization and adaption of fuel standard is mandatory
- ISO 14687-2 requires amendments to address key points: an overall purity value, without limitation to specific contaminants acting as catalyst poison or leading to degradation, cannot be accepted and some contaminants can be detrimental to FCV operation and reliability.
- A 5-micron filter at the nozzle is needed to stop particles from contaminating FCV's sensitive components at high pressure
- Appropriate monitoring of critical contaminants is to be implemented with research necessary to develop affordable monitoring and measurement methods
- Some impurities in ISO 14687-2 might be over-specified, vehicle OEMs together with gas suppliers are willing to revise ISO 14687-2 to achieve feasible fuel cost; these items will be proposed in TC197/WG24 of ISO (now under ISO19880-1)

Pre-concentration strategies for hydrogen fuel quality control (Shabbir Ahmed, US DoE-ANL)

- Presents results on different methods: (1) impurities TRAP on a sorbent (Adsorption) and (2) H2 removal by permeation (membrane) to facilitate the analysis and monitoring of trace species
- Analysis suits use with simple, inexpensive equipment
- Adsorption method is highly repeatable and fast for weakly adsorbing species
- Membrane method is effective for high and uniform enrichment and is adaptable for faster enrichment

Performing hydrogen fuel quality control - sampling strategies and challenges (Ole S. Kjos, SINTEF)

Analytical methods for quality control - potentials for cost reduction (Arul Murugan, NPL)

- Introduces Gas Sampling and Impurity Enrichment Device (GSIED) principle and operation method to allow for measurement of lower amount fractions, better signal-to-noise, useable with any analyser, and for offline or online enrichment possibility
- Presents hydrogen purity in the future by offline analysis, online analysis and offline analysis with enrichment

PEFC testing procedures assessing consequences of hydrogen fuel quality assurance (Jari Ihonen, VTT)

- HyCoRA Deliverable 1.1 results were shown. These indicate that conventional test station with single pass anode and low fuel utilisation (<85%) are insufficient for the hydrogen fuel contaminant work.
- The literature results indicate that the limits in ISO 14687:2-2012 can be too conservative for formic acid and formaldehyde as well as for sulphur, due to conversion to other species and in the cell and dissolution into water.

Risk assessment in HyCoRA project – need of data for the quantitative model (Risto Tuominen, VTT)

- Introduction of Bayesian Network (BN) model
- Highlights data needs for the BN-based risk models

4. Topics of discussions during presentations and final discussion and OEM guidance for HyCoRA project

- All OEM consider the risk model approach of HyCoRA project principally correct.
    - However, it was advised to keep the model simple, as quantitative data for the model may be difficult to achieve.
    - Supply chain specific QA requirements were supported.
- Automotive OEM consider hydrogen quality and price as key parameters for FCEV commercialisation
- Hydrogen quality can be monitored by monitoring PSA process parameters. Then, however, failure in process parameter monitoring will cause quality problem
    - As a consequence, risk mitigation can be done by improving process monitoring so that measurement sensors with no common failure mode are used
- Hydrogen quality is currently monitored by pass/fail criteria. Quantitative data from hydrogen producers can be available in the future, but this is not clear
- Monetary value for the loss of FCEV reputation will be difficult to estimate
- In some large hydrogen production plants H2 quality is frequently (continuously) monitored. Then the only possibility for H2 contamination in sold hydrogen is a failure in quality control of central production at the same time, when PSA purification is failing
    - This indicates that adding a second quality monitoring instrument could be efficient risk mitigations, assuming that there is no common failure modes
- Data from PSA model can be difficult to validate with the real process; however, in risk model PSA data could be used in the beginning without validation
    - ANL may be able to provide PSA model for the project use.

    - Data exists only for limited number of species for PSA modelling

- Continuous monitoring of canary species was considered as one way to have inexpensive risk mitigation methods. It was also considered possible that continuous monitoring may not have the same requirements as when doing full analysis for ISO 14687:2-2012 species

- Particulates were considered as a major issue, since large (over 0.005 mm) particles can be detrimental for the high pressure components of on-board hydrogen storage of the FCEV

- Halogenates were considered difficult to measure

    - If hydrogen is by-product from industry, then there is a real risk of chloride. Otherwise, the risk should be very small from the production (PSA purification, water electrolysis)

    - The risk of halogenate contamination due to supply chain is real, but should be quantified. Also, the risk of halogenate contamination due to supply chain can be minimised by improving operation and maintenance of the HRS. For this work, co-operation with HRS manufacturers is needed, in addition to hydrogen suppliers (tube trailers)

- In the current standard (ISO 14687:2-2012) formic acid and formaldehyde were considered very problematic to measure with the levels in the standard. As these are also the most probably contaminants having too low limits, it was advised that formic acid and formaldehyde should be further studied for providing data for te possible revision of ISO 14687:2-2012

5. OEM guidance for HyCoRA project

- It was advised to keep the risk model simple

- It was advised to include formic acid and formaldehyde as reversible contaminants, as these are complicated for the analysis and the experimental effort for the revision of the limits in ISO 14687-2:2012 could be reasonable