Publishable Summary for 15NRM03 Hydrogen
Metrology for sustainable hydrogen energy applications

Overview

Hydrogen is a clean and storable solution that could meet the worldwide energy demands. The new European policy objectives in the transport and energy sectors defined in the Horizon 2020 Research and Innovation programme encourage the decarbonisation of the transport sector in order to reduce the green-house gases effect. This project will address the standardisation needs in the hydrogen-energy sector that meet the requirements of the European Directive on the deployment of Alternative Fuels Infrastructure 2014/94/EU by revising two standards (ISO 14687-2 and ISO 16111) that are currently too generic to enable a sustainable implementation in the fast emerging sector of hydrogen fuel. Those revisions are stated in the business plan of ISO/TC 197 “Hydrogen technologies”.

Need

It is stated that the hydrogen purity dispensed at hydrogen refuelling points should comply with the technical specifications included in the ISO 14687-2 standard. The rapid progress of the fuel cell electric vehicles and related technology will require revising this standard towards less constraining detection limits as mentioned directly in the standard. While ensuring the hydrogen specifications, the application of the revised standard through optimised validated analytical methods will enable a reduction in the number of required analyses.

The increased transport and storage activities of hydrogen require the development of new and safe storage techniques for large quantities of hydrogen. The working group WG 25 “Hydrogen absorbed in reversible metal hydride” within ISO/TC 197 aims at improving the normative framework related to the ISO 16111 standard “Developing Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride”. The last version of 2008 of the standard presents technical limitations for large storage and issues of implementation. The standardisation work in this working group requires broadening the scope of the current standard to larger hydrogen volumes through traceable methods for the measurement of the amount of hydrogen absorbed in the metal hydrides (MH). Currently, the different methods available (i.e. mass methods, mass and volumetric flowmeters) do not provide accurate results.

Objectives

This project aims at evaluating the probability of hydrogen impurity affecting fuel cells and developing analytical techniques for traceable measurements of the hydrogen impurity (research axes for the revision of the ISO 14687-2 standard). Furthermore, it aims at developing and validating traceable methods to assess accurately the hydrogen mass absorbed and stored in metal hydrides (research axis for the revision of the ISO 16111 standard). The project will contribute to the standardisation development works through presentations and informative or normative guides.

The objectives are:

1. To develop hydrogen quality specifications for fuel cell vehicles, including tolerance levels for impurities in hydrogen and limits for the degradation of fuel cell performance as per ISO 14687-2 ‘Hydrogen fuel - Product specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles 2012’. This will include recommendations on maximum concentration of individual compounds based on the new fuel cell degradation studies and on the probability of presence.
2. To propose optimised analytical protocols (including fit-for-purpose analytical methods) and assess an analyser that enables the implementation of ISO 14687-2. The multicomponent analyser should have optimised sampling analysis and meet the required detection limits as per business plans ISO/TC 197

"Hydrogen technologies" 2005-11-07 and CEN/TC 268 "Cryogenic vessels and specific hydrogen technologies applications" 2014-04-04.

3. To develop and validate traceable methods for measuring the hydrogen mass absorbed in storage tanks (hydrides AB, AB2 and AB5), with reference to ISO 16111 "Developing transportable gas storage devices - Hydrogen absorbed in reversible metal hydride".

4. To contribute to the standards development work of key European and International Standards Developing Organisations ensuring that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity.

Progress beyond the state of the art

Development of hydrogen quality specifications for fuel cell vehicles

The current analysis techniques listed in ISO 14687-2 to measure hydrogen impurities are costly and time consuming for the actual increased end-use applications of hydrogen. The number of techniques required to achieve the very low concentration limits of these impurities is high. The project will provide a definition of the real harmful hydrogen impurities for proton exchange membrane (PEM) fuel cells through degradation tests on new generation of MEA. The probability of impurity presence in hydrogen will be evaluated by hydrogen production process expertise and by traceable measurements of impurities concentration in a representative number of hydrogen samples. Using these two studies, the project will draw up a novel risk analysis matrix table for hydrogen impurities to identify the key harmful impurities for PEM fuel cells with the new generation of MEA.

Proposal for a revised ISO 14687-2 standard

A revision of the ISO 14687-2 standard family is now combined with ISO 14687-1 (all applications except PEM fuel cell for road vehicles) and ISO 14687-3 (PEM fuel cell applications for stationary appliances) revisions into one single standard ISO 14687 (product specification). The new standard is at a committee draft level but further revision can be considered. A metrology appropriate analyser will also be proposed and validated for measuring key impurities on real hydrogen samples. New offline methods will be proposed for the impurities of most concern or adapted to the state-of-the-art.

Development of traceable methods for hydrogen mass measurements absorbed in metal hydrides: proposal for a revised ISO 16111 standard

There is a lack of standardised and traceable methods for the measurement of the amount of hydrogen absorbed in metal hydrides (MH), particularly for the increasing absorption capabilities of MH. A consistent method will be developed for traceable mass measurements of hydrogen absorbed in hydride tanks.

Results

Development of hydrogen quality specifications for fuel cell vehicles and risk analysis of impurities to manage and limit the degradation of fuel cell performance

The risk matrix of impurities (ammonia, Ar, CO, CO_2, formaldehyde, formic acid, H_2O, He, N_2, O_2, total halogenated compounds, total hydrocarbons compounds, total sulphur compounds) in hydrogen for fuel cells was investigated by evaluating the probability of impurities presence in steam methane reforming, electrolysis and chlor-alkali processes. Moreover, the first real samples of hydrogen from steam methane reforming and electrolysis process were sampled and analysed for the 13 gaseous impurities requested by ISO 14687-2 by the four European NMIs. New data on maximum concentration of individual impurity compounds based on the new fuel cell degradation studies and on the probability of presence will start for ammonia in hydrogen.

Development of optimised analytical methods for hydrogen impurity analysis

New speciation methods are under development for sulphur, halogenated and hydrocarbon species.

Results of the fuel cell degradation studies and the knowledge of the optimised methods for the hydrogen impurity analysis will be used to list the measurement instruments enabling the simultaneous analysis of

compounds mentioned in ISO 14687-2 with regard to the number of instruments/analyses needed, the method´s performance characteristics and the cost estimation. A recommendation report will be transmitted to ISO/TC 197 and provide input for the revision of ISO 14687-2. The exact form of this report will depend upon the request from the TC.

Traceable methods for hydrogen mass measurements absorbed in metal hydrides

For the determination of the best fitting system for hydrogen mass measurements, three hydride tanks have been made following the chronological conduct phases:

- design and validation of the tank
- manufacture of three tanks
- hydride production (melting, mashing, …)
- assembly of the tanks with hydride
- activation of hydride into the tanks
- validation of the characteristics of the hydride tanks

The hybrid (AB5) tanks will now be tested. Different methods for hydrogen mass measurements can be compared as sievert, mass or flow measurement. The AB5 hybride tanks will be tested using different measurement methods, the results will be compared and the deviation discussed to choose the best fitting method.

Impact

The first period of the project was conducive to a series of general presentations of the project and its objectives in regulatory bodies meetings at ISO, CEN and national levels. Although many of the tangible outputs are expected later in the project, the project has given a presentation at an international workshop on fuels cells and Hydrogen Technologies.

Impact on industrial and other user communities

The industrial and user communities of hydrogen are the targeted beneficiaries of the project outputs and the dissemination of the results through the applicable revised ISO 14687-2 and ISO 16111 standards. The uptake of the expected knowledge and methods included in the results of the project will have a direct effect on the European hydrogen industrial community: producers, consumers, distributors and manufacturers of analytical gas analysers and of storage tanks. The stakeholder advisory board comprising industrial parties first met in November 2016. Industrial stakeholders expressed the interest and need of the expected outputs of the project.

Impact on the metrology and scientific communities

The development of validated methods for hydrogen mass measurements in metal hydrides and instruments assessment will be performed to optimise and improve the implementation of the revised ISO 14687-2 and ISO 16111 jointly with a metrological validation and qualification. The project will involve international R&D laboratories, which attend standardisation meetings, in the development of analytical methods. These R&D laboratories will rapidly use the information and metrological quantification of hydrogen impurities to advance research on targeted techniques for specific and contaminating impurities.

Impact on relevant standards

The outputs of the project will have a direct impact on the standardisation works in the relevant working groups of the International and European regulatory bodies ISO/TC 197 “’Hydrogen technologies” and CEN/TC 268/WG 5 “Specific hydrogen technologies applications” with which the consortium has strong connections. The project and its objectives have been presented in regulatory bodies meetings at ISO level (TC 197, TC 158 JWG 7) and at CEN level (TC 268 WG 5 and SFEM WG Hydrogen). A report about the purity analysis of hydrogen in relation to documentary standard developments was submitted to the Dutch Ministry of Infrastructure and the Environment, which made the report (in Dutch) available to all Dutch stakeholders.

List of publications

There are no publications at this early stage of the project.

Project start date and duration:	1 June 2016, 36 months	
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