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Hydrogen monitoring requirements in the global technical regulation on hydrogen and fuel cell vehicles

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ABSTRACT

The United Nations Economic Commission for Europe Global Technical Regulation (GTR) Number 13 (*Global Technical Regulation on Hydrogen and Fuel Cell Vehicles*) is the defining document regulating safety requirements in hydrogen vehicles, and in particular, fuel cell electric vehicles (FCEVs). GTR Number 13 has been formally adopted and will serve as the basis for the national regulatory standards for FCEV safety in North America (led by the United States), Japan, Korea, and the European Union. The GTR defines safety requirements for these vehicles, including specifications on the allowable hydrogen levels in vehicle enclosures during in-use and post-crash conditions and on the allowable hydrogen emissions levels in vehicle exhaust during certain modes of normal operation. However, in order to be incorporated into national regulations, that is, to be legally binding, methods to verify compliance with the specific requirements must exist. In a collaborative program, the Sensor Laboratories at the National Renewable Energy Laboratory in the United States and the Joint Research Centre, Institute for Energy and Transport in the Netherlands have been evaluating and developing analytical methods that can be used to verify compliance with the hydrogen release requirements as specified in the GTR.

Introduction

The U.S. Department of Energy (DOE) Fuel Cell Technologies Office has taken the lead to support the development and deployment of hydrogen as an alternative energy source in the United States [1]. It supports DOE's mission to ensure the United States' security and prosperity by addressing energy and environmental challenges through transformative science and technology solutions [2]. Similarly, the European Commission identified the potential of hydrogen and fuel cells in the 2011 Technologies Map of the European Strategic Energy Technology Plan [3]. Hydrogen infrastructure and vehicles must be developed safely if hydrogen is to be used successfully as a fuel. One element of a hydrogen safety

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system is the use of sensors to detect and monitor unexpected hydrogen releases. Accordingly, sensor test facilities were independently established by the European Joint Research Centre (JRC) at the Institute for Energy and Transport [4] and by DOE at the National Renewable Energy Laboratory (NREL) [5] to ensure that hydrogen sensors are available to meet the needs of the hydrogen infrastructure and to educate the hydrogen community on the proper use of hydrogen sensors. These laboratories have ongoing collaborative sensor research programs formalized by a Memorandum of Agreement, and more recently under an agreement between DOE Fuel Cell Technologies Office and the Fuel Cell and Hydrogen Joint Undertaking (FCH-JU) of the European Union, in which it was agreed to collaborate on hydrogen sensor research. This agreement was the first formal international collaboration with common objectives between the hydrogen programs w ithin the United States DOE and FCH-JU. The goals were to identify gaps in current sensor technologies and to identify pathways to make available effective, cost efficient sensors. The EU activity was performed under the auspices of *H2Sense* [6], a FCH-JU–funded consortium of European sensor manufacturers and research laboratories. The U.S. activity was headed by the NREL Sensor Test Laboratory.

Global technical regulation number 13

United Nations Economic Commission for Europe Global Technical Regulation (GTR) Number 13 (*Global Technical Regulation on Hydrogen and Fuel Cell Vehicles*) [7] is the defining document regulating the safety requirements for light-duty hydrogen vehicles, and in particular fuel cell electric vehicles (FCEV). GTR Number 13 has been formally adopted and thus is to serve as the basis for the national regulations for FCEV safety in North America (led by the United States), Japan, Korea, and the European Union. Vehicle safety regulations are implemented and enforced by national authorities. A goal of the GTR is to provide a framework to internationally harmonize FCEV safety requirements to facilitate hydrogen vehicle market development and trade. Accordingly, national authorities overseeing development and enforcement of vehicle regulations in their respective jurisdictions shall endeavor to harmonize their national regulations with the GTR. Within the United States, the national authority for vehicle safety is the U.S. Department of Transportation (DOT), National Highway Traffic Safety Administration (NHTSA) and the prevailing regulatory code is the Federal Motor Vehicle Safety Standard. Under the terms of the agreement for the implementation of the GTR, national authorities overseeing vehicle safety regulations are required to make a “good-faith” effort to harmonize their respective regulations with the GTR by either complying with the terms as they currently exist or by appealing to change specific terms or requirements within the GTR deemed unacceptable. Therefore, compliance with the GTR is not absolutely mandatory, and national regulations are able to deviate from the GTR requirements provided an attempt for harmonization was made by the respective national authority. An opportunity to formally recommend revisions to the current version of the regulation is tentatively scheduled for late 2016.

The GTR covers electrical, mechanical, pressure, and other safety requirements for FCEVs. Included within the GTR are safety requirements on allowable hydrogen emission levels in vehicle enclosures during in-use and post-crash test conditions and on the allowable hydrogen content in vehicle exhaust during certain modes of normal operation. However, in order to be incorporated into national regulations, that is, to be binding, methods to verify compliance with the specific requirements must exist. In a collaborative program, the sensor laboratories at NREL in the United States and the JRC in the Netherlands have been developing analytical methods that can be used to verify compliance with the hydrogen emission requirement as specified in the GTR. There are two specific requirements defining allowable hydrogen releases specified in the GTR. These are presented in Section 5 of the GTR (Performance Requirements). The specific hydrogen release requirements are:

GTR Section 5.2.1.3.2 – Vehicle exhaust system.

At the vehicle exhaust system's point of discharge, the hydrogen concentration level shall:

(a) Not exceed 4 percent average by volume during any moving three-second time interval during normal operation including start-up and shutdown;
(b) And not exceed 8 percent at any time.

GTR Section 5.2.2.2. Concentration limit in enclosed spaces (Post Crash Test Integrity)

Hydrogen gas leakage shall not result in a hydrogen concentration in the air greater than 3 ± 1.0 percent by volume in the passenger, luggage and cargo compartments.

The NREL and JRC sensor laboratories have ongoing activities to address both released hydrogen detection requirements as listed in the GTR and summarized above. This information has been shared with the DOT to provide DOT with tools to verify compliance with the GTR requirement or to supply normative data to support recommendations to modify the current requirements. The results of this research are presented below.

Vehicle crash test requirements

Sensors and methods for monitoring hydrogen/helium in FCEV crash tests

The NREL and JRC sensor laboratories completed two studies pertaining to the hydrogen monitoring requirements specified in Section 5.2 of the GTR for fuel system integrity following vehicle crash tests. In the first study, NREL had the opportunity to instrument a demonstration FCEV with hydrogen sensors in an actual crash test. This was performed in cooperation with the DOT NHTSA. The goal of the project was to identify a sensor or sensor method that could respond to either hydrogen or helium releases, identify a technology that could survive the impacts of vehicle crash tests and still meet the metrological requirements for verification of the FCEV fuel system integrity as per the GTR requirements, and to develop a method for on-board monitoring of the sensor either in real time or extractable for post-crash test analysis. The results of