U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FUEL CELL TECHNOLOGIES OFFICE

REPORT ON RFI DE-FOA-000753:

High-Accuracy Hydrogen Meters[1]

RFI issued:	**August 2012**
RFI closed:	**September 2012**
Report issued:	**June 2013**

Introduction: As the 2015 roll-out of widely-available commercial Fuel Cell Electric Vehicles (FCEVs) approaches, meters that can accurately measure the hydrogen fuel dispensed at stations are needed, to protect both the customer and vendor. To better understand the current status of meters for hydrogen fueling, the Fuel Cell Technologies Office (FCTO) examined publically available documents and issued a Request for Information.[2] Presented here are the general conclusions, excluding any proprietary/company sensitive information. In brief, while there are technical challenges to developing meters that meet the requirements, non-technical issues such as lack of demand and testing facilities are also barriers.

This inquiry focused on the meters to be installed in dispensing devices, rather than on the master meters used to calibrate and certify the accuracy of the dispenser systems. The two meter types face different challenges: for example, master meters must be more accurate but do not have to operate under the fueling environment. There are three basic meter types, gravimetric, volumetric, and mass flow rate, but mass flow rate meters are the most likely candidate for dispensers due to the accuracy and rapid continuous reading required to meet the standards required to publicly sell hydrogen fuel by weight (e.g., $/kg).

Meter characteristics are generally defined by two sets of requirements: they must meet legal measurement requirements (e.g., National Institutes of Standards and Technology (NIST) Handbook 44[3]), and perform under fueling conditions (currently defined by SAE TIR J2601[4]). Most meters surveyed for hydrogen fueling are coriolis-type meters, based in part on their current use for Compressed Natural Gas (CNG) fueling. Publicly available information gathered before the RFI suggested that meters that could handle the pressures and temperatures required by the fueling protocols would have an accuracy of approximately 5-10%.

Legal measurement requirements: To legally sell hydrogen fuel to the public, stations will need to meet the requirements sent by local authorities, many of whom look to NIST as a guide. Hydrogen fuel sale by weight is covered by the NIST Handbook 44, section 3.39, Hydrogen Gas-Measuring Devices. This section is a tentative code, designed for study before the adoption of final codes. The proposed error tolerance for device acceptance is 1.5% for the entire dispenser system, for any conditions that fueling can occur (e.g., across all allowed flow rates).

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[2] http://www1.eere.energy.gov/hydrogenandfuelcells/news_detail.html?news_id=18541

[3] http://www.nist.gov/pml/wmd/h44-12.cfm

[4] http://standards.sae.org/j2601_201003/

Fueling conditions: Though many dispenser designs are possible, it is likely that the meter will be placed after compression and cooling and will need to perform under the fueling conditions. The technical information report, SAE TIR J2601, currently in the review process, provides guidelines for fueling protocols. More information can be found in a recent FCTO webinar[5]. Focusing on the 700 bar systems expected for roll-out in 2015, key hydrogen fueling conditions relevant to meter performance described by the SAE J2601 technical information report are:

- Fill pressure: 700 bar nominal working pressure (875 bar maximum station fueling pressure)
- Pressure pulse: a maximum pressure of 875 bar
- Flow rate: Up to 3.0 kg/minute, with a lower limit of 0.08 kg/min (calculated from tables)
- Hydrogen temperature: lower limit of -40 C to ambient temperature (depending on fueling station type), upper limit of 85 C (tank temperature limit)
- Ambient temperature: -40 C to 50 C

Other considerations: Other considerations include safety requirements, use of hydrogen-compatible materials, and maintenance and calibration requirements.

General conclusions: The RFI received 11 responses from seven organizations, representing a wide range of stakeholders. Meters across a wide range of development stages were discussed.

Technical challenges: No insurmountable technical challenges were identified that would prevent the development of meters that meet all the criteria, given time and support:

- No meter meets all requirements simultaneously: At least one meter could meet each of the target criteria, but none met all criteria simultaneously. In some cases there are direct trade-offs between criteria – for example, a meter that reaches the higher pressure range may use materials that are incompatible with hydrogen.
- Accuracy requirement not met: No meter compatible with the high pressures and low temperatures of the fueling protocol could reach 1.5% accuracy, though at least one meter design in near-term development was estimated to reach error rates below 5% under those conditions.

Non-technical challenges: Several non-technical issues were identified by the responses as barriers to development:

- Lack of testing facilities: To best mimic real-world performance, meters need to be tested under fueling conditions, including the physical requirements (e.g., high pressures and low temperatures), as well as the rapidly varying conditions expected at an active fueling station servicing multiple vehicles daily. The current inability to test under relevant conditions is a barrier both to developing meters and to assessing the current state of the technology.
- Dispenser system testing: Dispenser design affects required meter characteristics, by determining the conditions the meter is exposed to, and introducing some amount of inaccuracy, which must be known to determine how accurate the meter must be for the entire system to reach 1.5% accuracy.
- Current lack of a market: The current low demand does not provide an incentive to invest in the development of high-accuracy meters for fueling.

[5] http://www1.eere.energy.gov/hydrogenandfuelcells/webinar_archives_2013.html#date022213