

H2 metering study - Certification of hydrogen dispensers

Contract No: FCH / OP / 196

**FCH-JU Program Review Day - Nov 14th,
2018**

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**GLOBAL MARKETS
& TECHNOLOGIES**

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1. Background on Hydrogen Flow Metering

- **Flow meters are not approved** according to OIML R139 due to the absence of testing facilities in Europe (H₂, 700 bar, ...)
- Existing **OIML R139-2014** is not adapted for hydrogen dispensers
 - Accuracy, MMQ, Durability test, Tests at constant flow rate
→ *Currently in revision (expected for beginning of 2019)*
- Until beginning of 2018, **no certified reference testing device** in Europe to determine the global accuracy → *of meters and dispensers*
- Up to now the sale of H₂ without certified flow meter is **tolerated** by the authorities (demonstration projects, limited group of users)
 - By entering the commercial phase with extension of the HRS network, **uncalibrated sales of H₂ cannot be tolerated anymore**
- Pressure of the Offices of Weights and Measures (Eichämter) is currently increasing, especially in Germany
→ **Therefore, short-term solution for the approval H₂ dispensers is necessary for the further ramp-up of the HRS network in Europe**

2. FCH-JU tender on H2 Metering

- **Specific tender launched by FCH-JU in May 2017:**

FCH-JU Study “Development of a Metering Protocol for Hydrogen Refuelling Stations” (Contract No: FCH / OP / 196)

- Air Liquide applied and was selected for this tender
- Study started in Nov 2017

- **Scope:**

- **Task 1:** “Development of a testing protocol for HRS regarding compliance with OIML R-139”
- **Task 2:** “*Design and implementation of a test campaign*”
- **Task 3:** “Agreement from relevant national authorities/institutes”

- **Expected outcomes:**

- A protocol for an accelerated certification of existing and future HRS
- Results of accuracy tests for several HRS
- Support from several stakeholders to apply this protocol in their respective countries

2. FCH-JU tender on H2 Metering

- **Partnership:**

- National Metrological Institutes:
 - PTB (*Physikalisch-Technische Bundesanstalt*) in Germany: **Dr Rainer KRAMER**
 - LNE (*Laboratoire national de métrologie et d'essais*) in France: **Mr Christophe BRUN**
 - NMI Certin in the Netherlands : **Mr Erik BEUMER**
- Laboratory expert in gaseous flow metering:
 - LNE-LADG / Cesame Exadebit s.a. in France: **Dr Rémy MAURY**

- **Task 1:**

- Status: **finished**
 - Started in November 2017 and ended in February 2018

- **Task 2:**

- Status: **on-going**
 - Started in August 2018 and is expected to be finished in February 2019
- 3 HRS tested over 7 HRS overall

- **Task 3:**

- Status: **on-going**
 - Started in Oct 2018 and is expected to be finished in March 2019

3. Protocol for HRS certification

- **The following approach has been followed:**

- **OIML R139:2014** is the reference
- Main components of the measuring system (calculator and meter) are approved according to different standards:
 - **OIML R139:2007**
 - **OIML R117-1:2007** or **OIML R117-2:2014**: “*Dynamic measuring systems for liquids other than water*”
 - **OIML R137:2012**: “*Gas meters*” (for meters only, not applicable to calculator)
- Assessment of deviations to OIML R139:2014 for these components for each category of tests required for Type Approval:
 - Electromagnetic compatibility (EMC)
 - Environment testing (climatic test, humidity, etc.)
 - Accuracy tests
 - Gas temperature accuracy tests
 - Durability tests
 - Software (WELMEC 7.2)

→ **Decision is made to require, or not, complete new tests or additional tests**

- Evaluation for existing stations already in operation AND future new stations that will be certified according to this protocol: for both Type Approval and Initial Verification.

3. Protocol for HRS certification

Legend:

1 = Complete new tests

2 = Additional test required

3 = No test required

4 = No test required, but under conditions

() = specific for existing HRS

Details in the public deliverable:

<https://www.fch.europa.eu/publications>

		Calculating & indicating device		Measurement transducer (electronics) & Measurement sensor	
		Certified according to: OIML R117-1:2007 or OIML R139:2007	Certified according to: OIML R117-2:2014 or OIML R139:2014	Certified according to: OIML R117-1:2007 or OIML R139:2007 or OIML R137:2012	Certified according to: OIML R117-2:2014 or OIML R139:2014
Type approval tests	EMC	2 (3)	3	2 (3)	3
	Environment testing (climatic test, humidity)	3		3	
	Mechanical test (vibration)	3 if M1		3 if M1	
	Accuracy test	3		1	
	Accuracy gas temperature tests	3		4	
	Software (WELMEC 7.2)	4	3	4	3
	Durability test	3		4 (3)	
Initial verification	Adjustment on site		1		

3. Protocol for HRS certification

- Note: Accuracy classes for hydrogen dispensers**

- OIML R139 revision initiated in **March 2017** to include specificities of Hydrogen dispensers
- Accuracy classes have been largely discussed and revised:
 - **Class 2 & Class 4** have been created for hydrogen service

Table 1 - MPE values

Accuracy class	MPE for the meter [in % of the measured quantity value]	MPE for the complete measuring system [in % of the measured quantity value]		
		at type evaluation, initial or subsequent verification	in-service inspection under rated operating conditions	
For general application	1.5	1	1.5	2
For hydrogen only	2	1.5	2	3
	4	2	4	5

Note 4: For hydrogen the accuracy class 2 is preferred though national authorities may decide to require the accuracy class 4.

- In principle: **Class 2** is accepted for future stations, whereas **Class 4** is tolerated for existing stations

Class 2: MPE = 2%, and 4% for MMQ

Class 4: MPE = 4%, and 8% for MMQ

4. Testing device

- **Testing device designed and manufactured by Air Liquide**

- Certified by PTB (March 2018) as first reference standard for calibration, conformity assessment and verification of hydrogen refuelling dispensers
 - Also accepted by LNE (France) and NMI Certin (Netherlands)
- Fulfills metrological requirements as per OIML R139
 - Uncertainty $U < \frac{1}{2} MPE = 0,3\%$
 - Uncertainty budget defined in collaboration with PTB / LNE

- **Approvals:**

- CE, ATEX
- Check-list for installation and safe operation of the testing equipment (according to German rules)



Bericht
Report

**METERING TEST BENCH
for hydrogen refuelling station
in accordance to SAE J2601**

**Messeinrichtung
für Wasserstoffbetankungsanlagen
nach SAE J2601**

der/of

AIR LIQUIDE
Advanced Technologies
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Usage for the conformity assessment and verification
for legal metrology purposes
Einsatz für Konformitätsbewertungen und Eichungen
im Rahmen des gesetzlichen Messwesens

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On behalf of PTB


Dr. Roland Schmidt

Braunschweig, 2018-03-26

Siegel
Seal



Im Auftrag
On behalf of PTB


Dr. Rainer Kramer

4. Testing device

- **Main characteristics**

- **High precision scale:** resolution 0.2g, Ex-certified
- **Composite tank** of 104L (i.e. 4,0 Kg of Hydrogen at 700 bar, 15°C)
- **Mobile** test bench (trailer) to be moved on each HRS
- Trailer walls, doors and roof serve as **protection against wind:**
 - very stable measure, even with strong wind conditions
- Improved **depressurization system:**
 - Reduce depressurization time while ensuring integrity of the tank (wrt min temp)
 - Depressurization time (from 700 to 20 bar): *1h30 to 1h45*
- Possibility to remove the scale for transport
- Valve panel to **inert tank with N2** for transport
- Independant **vent stack** for depressurization of the tank



5. Test campaign and preliminary results

- **Selection criteria:**

- All technologies and/or specificities should be tested
- HRS from different manufacturers in Europe: Air Liquide, Linde and H2 Logic (NEL)
- HRS in operation in minimum 3 different countries of the European Union

- **HRS technologies (criteria 1 & 2)**

- **Air Liquide:** compressed gas
- **Linde:** liquid hydrogen (cryo pump) & compressed gas (ionic compressor)
- **NEL:** compressed gas

- **Selection of additional HRS in Europe (criteria 3)**

- Germany (mainly) / France / Netherlands

→ **In total, 7 HRS will be tested**



Kamen - Air Liquide



Cologne - Linde



Rostock - Nel

5. Test campaign and preliminary results

- **Test Program for Accuracy Tests:**

- 3 x Full Filling: 20-700 bar
- 3 x Partial Filling: 20-350 bar
- 3 x Partial Filling: 350-700 bar
- 12 x MMQ (1kg)

- **Recording further data:**

- Environmental conditions : ambient temperature, wind velocity, humidity
- Filling conditions: pressure ramp, temperature, flow rate)
- Start/final pressure and mass

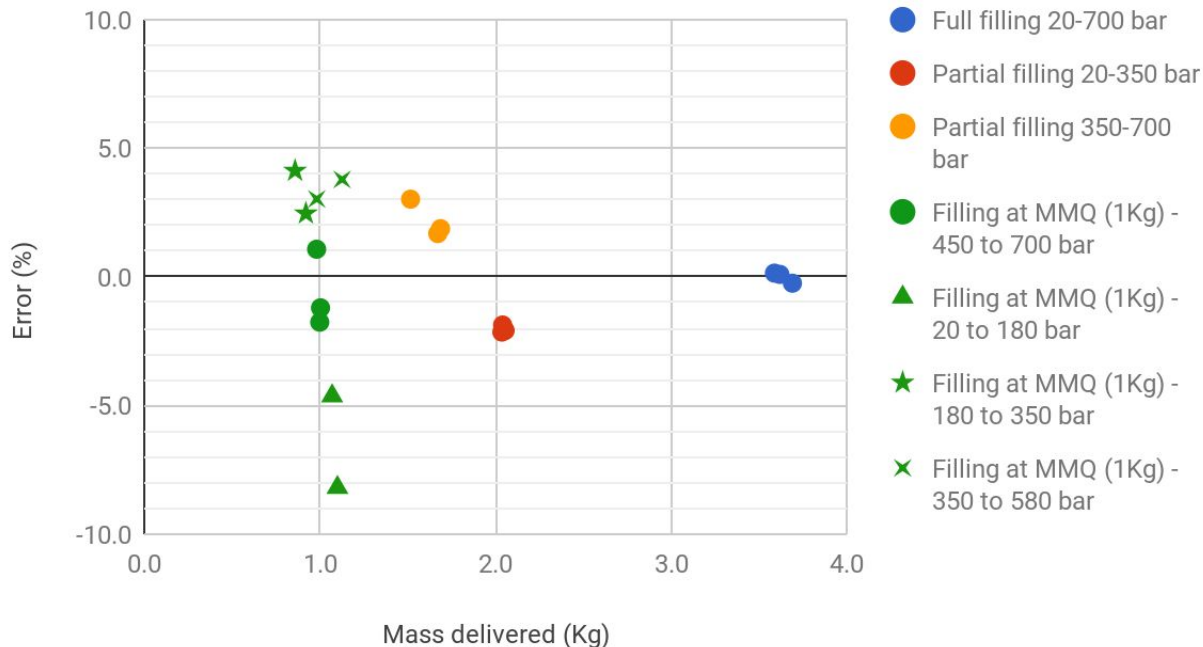
- **Duration for one Test Campaign:**

- At least **4 days are needed**, including installation due to long time for depressurization (1.5h for a full tank)



5. Test campaign and preliminary results

Measured accuracies - Kamen - with adjustment



5. Test campaign and preliminary conclusions

- **Good reliability of the testing device**
- **No big influence of the type of MFM**
 - To be further investigated with other HRS
 - Good precision of the 2 MFM tested (cf. Full fillings) and good overall repeatability
- **High influence of the distance between the MFM and the dispenser**
 - The longer the distance (volume), the bigger the error
 - Error can be calculated knowing the precise volumes

	Kamen <i>(based on adjusted values)</i>	Koblenz	Cologne
Full fillings 20-700 bar	0,00%	-0,32%	0,52%
Partial fillings 20-350 bar	-2,03%	-3,84%	-2,46%
Partial fillings 350-700 bar	2,19%	4,05%	0,72%
Filling at MMQ 450 to 700 bar	-0,63%	0,08%	1,99%
Filling at MMQ 20 to 180 bar	-6,41%	-10,02%	-9,95%
Filling at MMQ 180 to 350 bar	3,29%	3,28%	-5,13%
Filling at MMQ 350 to 580 bar	3,41%	3,69%	-1,08%

6. Summary

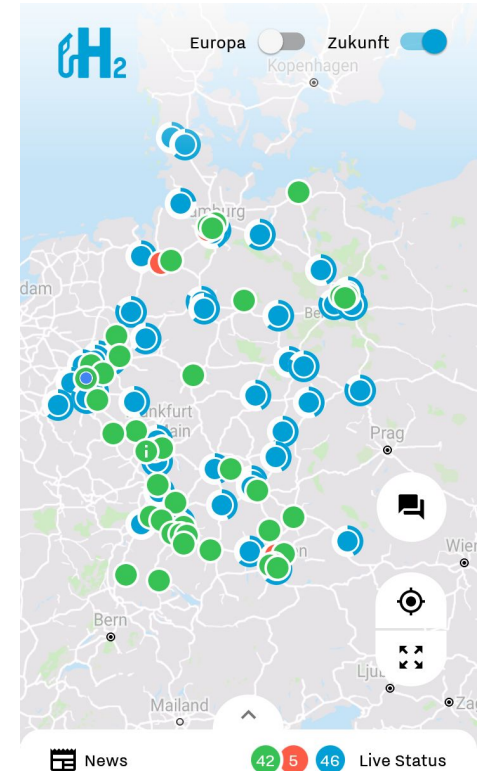
- **Conclusions:**

- Good test results with a high repeatability
- Test Bench and test results are **highly appreciated by PTB and the Offices of Weights and Measures**
- Test results are good baseline for further discussions with the National Authorities, especially the German Offices of Weights and Measures (Eichämter)

- **Next steps**

- **Developed test protocol has to be endorsed by further NMIs**
- Finalize the type approval approval process for new HRS and start the on-site verification

→ **In the next years more than 100 HRS have to be certified!!!**



A small sign on the underside of a white canopy, featuring the Air Liquide logo and the text "Air Liquide" in red.

Air Liquide

Thank you for your attention!
#TeamWasserstoff

A large white sign with the Air Liquide logo and the text "Air Liquide" in red.

Air Liquide

**Wasserstoff-
Station**