METROLOGY for HYDROGEN VEHICLES 2

Metrology for Hydrogen Vehicles 2 : " *OIML R139:2018 and shortcomings"*

Rémy MAURY & Henri FOULON (LNE-LADG / **CESAME**-EXADEBIT)
on behalf of the WP1 partners

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OIML R139:2018 and shortcomings

Road Map

- **Introduction**
- **Contents of OIML R139:2018**
- **Requirements on HRS**
- **Tests programs**
- **Shortcomings**

Introduction

- OIML (Organisation Internationale de Métrologie Légale) = International Organization for Legal Metrology www.oiml.org
- Aim: global recommendations for worldwide equal requirements and testing methods in legal metrology
- Different kind of documents (guides, basic docs, recommendations etc.)
- OIML-D general description of special issues
  - D 11 General requirements for measuring instruments -Environmental conditions
  - D 32 General requirements for software-controlled measuring instruments
- All member states are invited to use recommendations as basis for national legislation
- New certification system "OIML-CS" has started for improved mutual recognition of test results

OIML R139 and Hydrogen (gaseous)

- Currently managed by OIML TC8/SC7 (secretariat : M. VAN DER WIEL, NL)
- OIML R139:2014 -> ' Compressed gaseous fuel measuring systems for vehicles'
  but ... all parameters were adapted to CNG only
- R139 was amended in 2018 for integration of HRS measuring systems (Hydrogen Refueling Stations)
  - Necessity of additional MPE (Max Permissible Errors) because of H2 high pressure (70 MPa) and gas temperature
  - No changes of other parts planned, but finally some changes were done like for durability test.

  - Part 1: Metrological and technical requirements
  - Part 2: Metrological controls and performance tests
  - Part 3: Test report format

OIML R139 contents

Special features for Hydrogen Refueling Stations

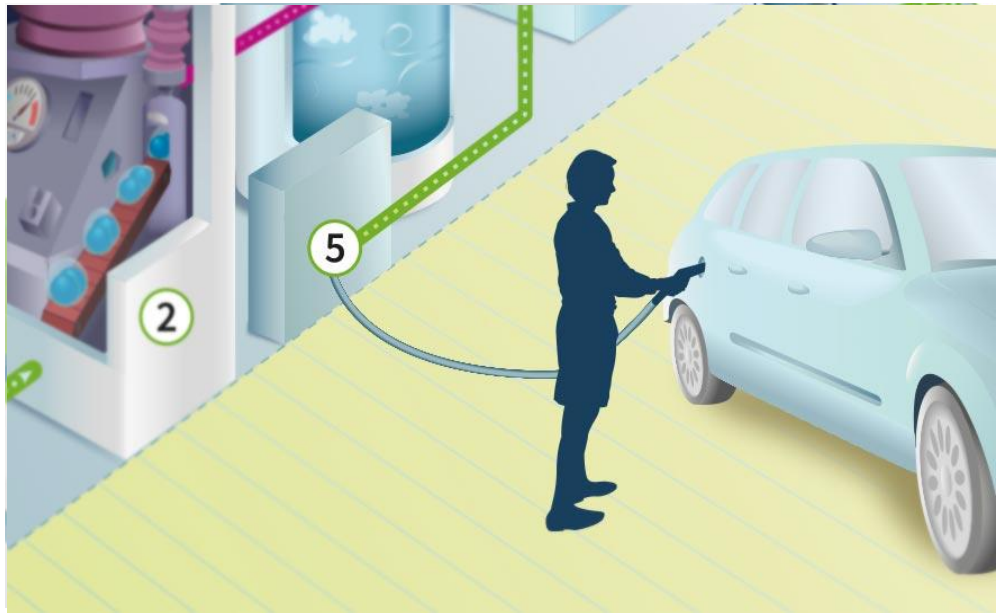
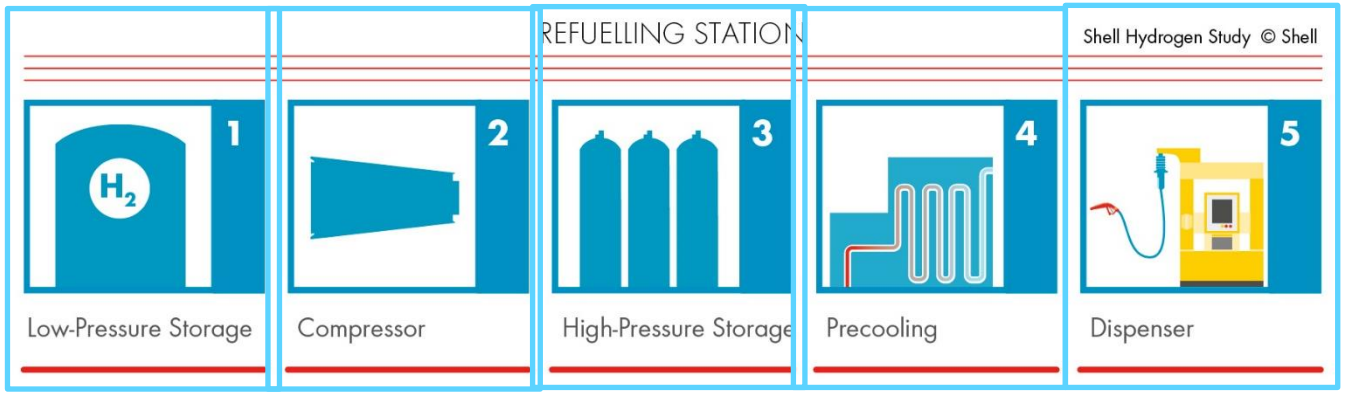
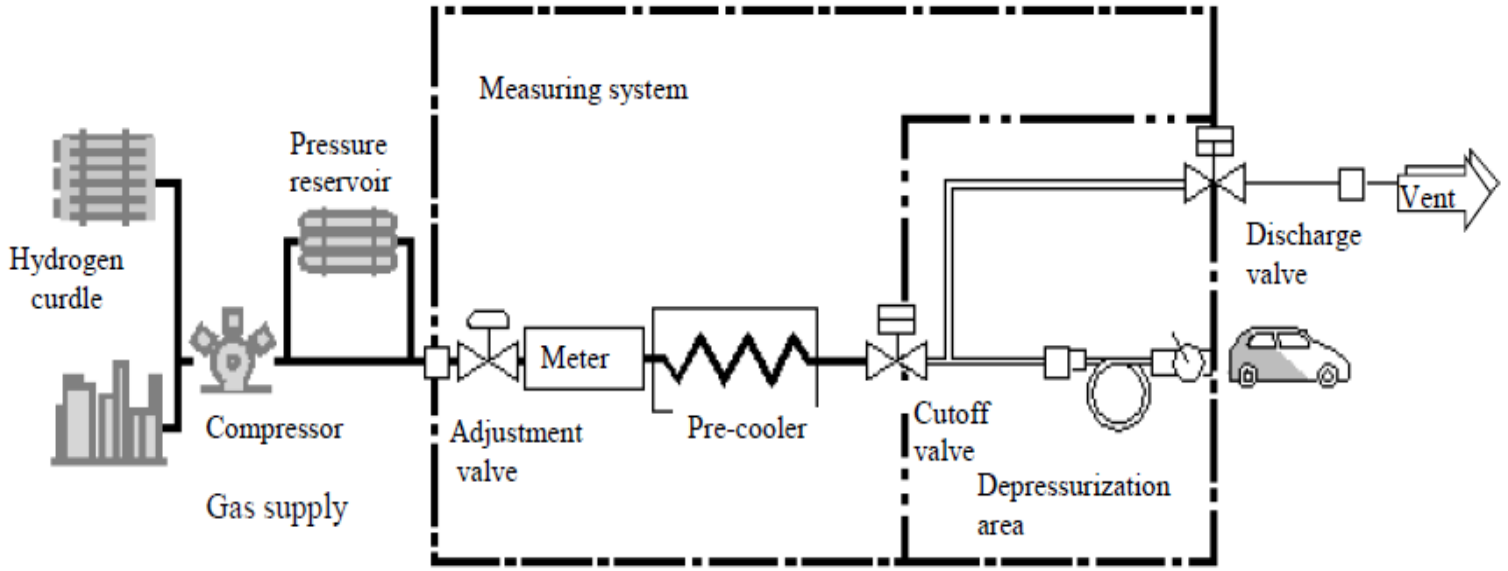


Photo courtesy of the California Fuel Cell Partnership



OIML R139 contents

Special features for Hydrogen Refueling Station



- **According to (usual) refueling protocol (SAEJ2601-1), hydrogen shall reach -40 °C after 30 seconds for "H70" dispensers (and for some H35 ones) in order to allow maximum filling capacity, whereas it is at ambient temperature for CNG**
- **Pressure control valve is used to generate pressure ramp (APRR, Average Pressure Ramp Rate, MPa/min) at the nozzle (depending on parameters like current ambient temperature, tank volume)**
- **Venting quantity could matter greatly (depending on architecture) , compared for instance to 3.5 kg of H2 for a full filling @ 70 MPa in a LDV 100L tank**

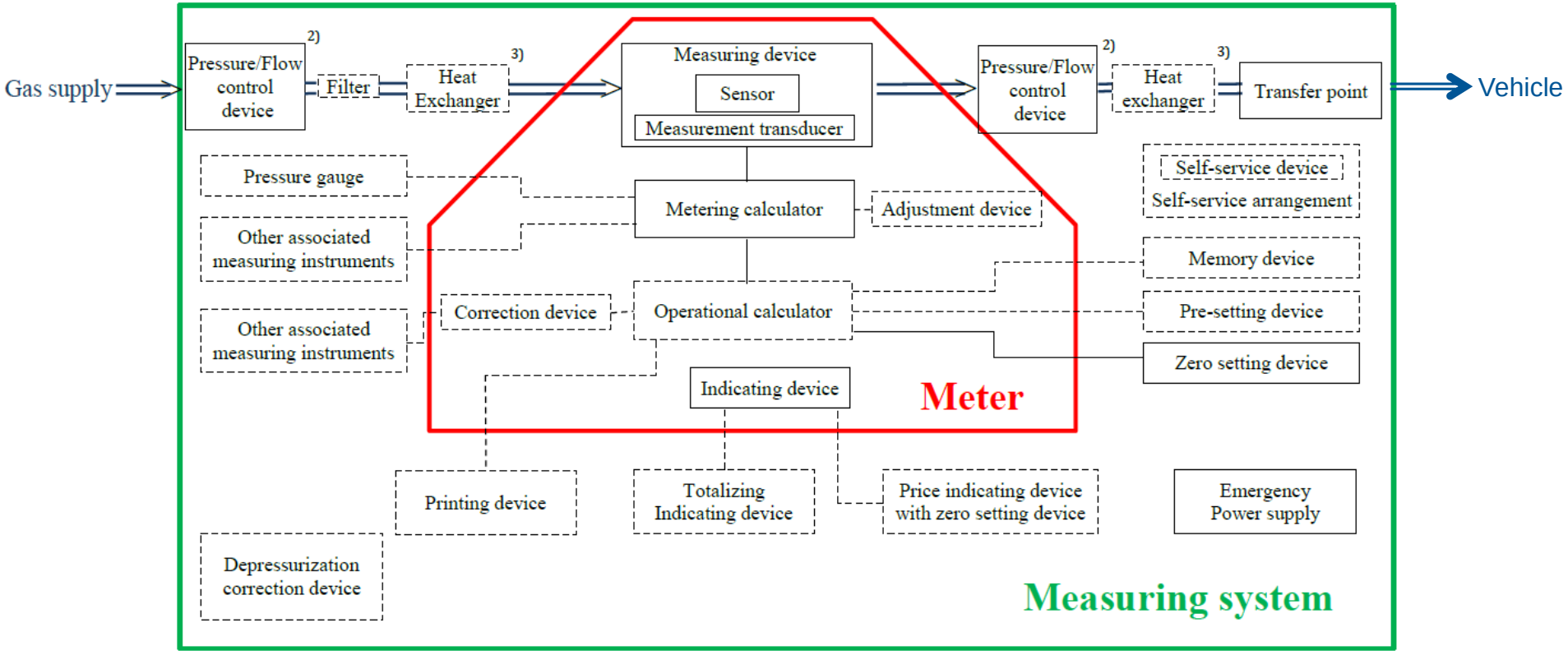
OIML R139-1 : Main points

1. Introduction
2. Scope
3. Terminology
4. Description of the measuring system and its constituents
5. Metrological requirements for the measuring system
   - 5.1 Presentation of the measurement result
   - 5.2 Maximum permissible error (MPE) and MMQ (Minimum Measured Quantity)
   - 5.3 Measuring range
   - 5.8 Durability
6. Technical requirements for the measuring system
7. to 10: Markings, documentation…
11. Suitability for testing
15. Additional requirements for specific modules
    - 15.1 Meter

- Annex B : Typical methods for correction of the depressurization quantity for hydrogen CGF (Compressed Gas Flowmeter) measuring systems

OIML R139-1 contents

section 4 / measuring system and its constituents



- **Constituents of a typical compressed gaseous fuel measuring system for vehicles**

OIMLR139 contents

section 5.2 / MPE, Maximum Permissible Error

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

- **New MPEs classes have been created for hydrogen only**
- **Class 2 are usually targeted by the national authorities, but class 4 could be accepted**
- ***Quick comment : there is currently no capability in the world to calibrate the meter separately with H2 at 875 bar up to 3.6 kg/min (Cars) or 7.2 kg/min (LDV)***

OIMLR139 content

section 5.2 & 5.3 / MMQ (Minimum measured quantity) for H2

- **MMQ for all types of Hydrogen CGF measuring systems is at 1 kg MAX**
  not proportional to the delivered quantity : 1 kg for car (4kg of H2), 1kg for trucks (40 to targeted 100kg of H2

- **for MMQ, MPE is twice the one defined for H2 mass > 1 kg**

Accuracy class	E_{min} [g; kg]		
	for the meter	for the complete measuring system	
		at type evaluation, initial or subsequent verification	at in-service inspection
1.5	0.02 MMQ	0.03 MMQ	0.04 MMQ
2	0.03 MMQ	0.04 MMQ	0.06 MMQ
4	0.04 MMQ	0.08 MMQ	0.1 MMQ

OIML R139 contents

section 5.8 / Durability

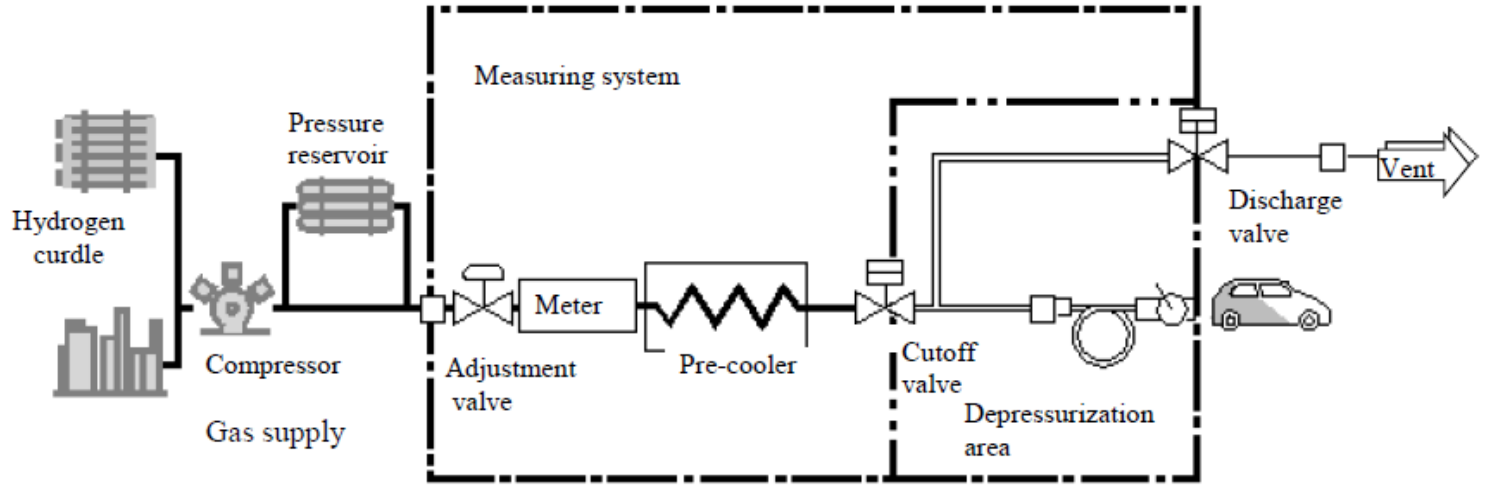
- After at least 100 hours of operation at 0.8 Qmax, the meter shall not drift more than ±1 % of the measured quantity
- durability performance criterion is the satisfactory completion of 2000 deliveries
- <u>For meters without moving parts</u> : << Coriolis meters

  - providing documented information showing the fulfilment of the durability performance criterion

<u>Remark</u> : Documented information may be a lifetime estimation based on test results…

OIML R139-1 contents

Annex B / methods for correction of the depressurization quantity



- **Evaluation by different methods permitted :**
  - **calculation based on relevant (estimated) values of p,T and V**
  - **calculation based on measured flow or p and T values**

Note: depending on the location of the flow meter the venting quantity can be on the same order of the MPEs (applies mostly for older HRS design)

OIML R139-2 : Main points

1. Metrological controls
   - 1.3 Uncertainty
2. Instrument evaluation
   - 2.2.5 Performance tests on the measuring system/ preconditions
3. Type evaluation
   - 3.5.3 Measuring systems specific for Hydrogen fuel
4. Initial verification (measuring system)
   - 4.6 Tests at initial verification
     - 4.6.7 Alternative procedure for Hydrogen CGF measuring systems
     - 4.6.6 Alternative procedure
5. Subsequent verification (measuring system)
   - 5.2 Tests at subsequent verification

- Annex A minimum test quantities for measuring systems and devices
- Annex B Test methods for influence quantities for Coriolis meters

OIML R139-2 contents

section 1.3 / Test facility uncertainty Ue (k=2)

For type approval → less than 1/5 of the applicable MPE → primary standard required

For verifications → less than 1/3 of the applicable MPE → secondary standard *could be* used

If the above-mentioned criteria cannot be met than reduced acceptance criterion shall be applied

For type approval → +/- (6/5 MPE – U)

For verifications → +/- (4/3 MPE – U)

Reaching a comparable confidence interval, a measuring is not outside MPE

OIML R139 content

section 2.2.5 / preconditions for performance tests

Test receiver volume	Meter capacity					Unit
	$Q_{max} \leq 4$	$4 < Q_{max} \leq 12$	$12 < Q_{max} \leq 30$	$30 < Q_{max} \leq 70$	$Q_{max} > 70$	kg/min
V_{min}	10	30	90[1)]	300	600	L

Note that distinction should be made between Qmax for the meter (could be larger) and Qmax for the measuring system (could be related to fueling protocols)

This table indicates that the *Test receiver volume must* allow the maximum flow rate defined for the dispenser.

But according this table:

- **3.6 kg/min H2** (for cars & LDV @ 700 bar or normal fueling of LDV @ 350 bar, cf SAE J2601-1) **-> Vmin receiver = 10 L,**
- **7.2 kg/min H2** (for fast fueling of LDV @ 350 bar, cf SAE J2601-2) **-> Vmin receiver = 30 L !**

Obviously, this OIML table has not been duly revised for Hydrogen testing, while SAE J2601 demands minimum tank volume (CHSS; Compressed Hydrogen Storage System) for allowing refuelling process

Table 4 - CHSS capacity categories

Pressure Class	Total Amount of Hydrogen in CHSS at 100% SOC (kg)	Water Volume of CHSS (L)	CHSS Capacity Category Identifier
H35	1.19 to 2.39	49.7 to 99.4	A
H35	2.39 to 4.18	99.4 to 174.0	B
H35	4.18 to 5.97	174.0 to 248.6	C
H70	2.00 to 4.00	49.7 to 99.4	A
H70	4.00 to 7.00	99.4 to 174.0	B
H70	7.00 to 10.00	174.0 to 248.6	C
H70	>10.00	>248.6	D

OIML R139-2 contents

section 3.5.3: Type Evaluation of measuring system / Tests program for H2

Test #	Initial state
Test 4	Initial test receiver pressure of 0 kPa or higher if so required for safety reasons Initial station storage pressure at P_{st}
Test 5	Initial test receiver pressure of 0.5 P_v Initial station storage pressure at P_{st}
Test 7 (minimum measured quantity)	The conditions for test 3 or 6 are adapted in order to test the minimum measured quantity. For this purpose, the pressure does not have to be P_v in the test receiver at the end, but may be any pressure (as close as practical to P_v) such that the quantity of transferred gas shall be at least the minimum measured quantity.

+

Ue $_{(k=2)}$ of reference < 1/5 MPE

#4,#5,#7,#4,#5,#7,#4,#5 –> 8 tests

For MMQ (1 kg max) , the test should be realized close to Pv

Pst = maximum station storage pressure, Pv = Allowed maximum gas pressure in the receiver

Note: *Today, Gravimetric reference for tests => Type IV tanks =>* ***2 days for this Test Program*** *(including facility installation, scale calibration, flushing and preparation for departure) , largely due to precautious defueling and cleaning of tanks after each tests (estimated around 1h30 per test)*

OIML R139-2 contents

section 4.6.7: Initial Verification of measuring system / Tests / " Alternative procedure for Hydrogen CGF measuring systems"

Test #	Initial state
Test 4	Initial test receiver pressure of 0 kPa or higher if so required for safety reasons Initial station storage pressure at P_{st}
Test 5	Initial test receiver pressure of 0.5 P_v Initial station storage pressure at P_{st}
Test 7 (minimum measured quantity)	The conditions for test 3 or 6 are adapted in order to test the minimum measured quantity. For this purpose, the pressure does not have to be P_v in the test receiver at the end, but may be any pressure (as close as practical to P_v) such that the quantity of transferred gas shall be at least the minimum measured quantity.

+

Ue $_{(k=2)}$ of reference < 1/3 MPE

#4,#5,#7,#4,#5,#7,#4,#5 –> 8 tests

For MMQ (1 kg max) , the test should be realized close to Pv

Pst = maximum station storage pressure, Pv = Allowed maximum gas pressure in the receiver

Note 1 : R139 defines in § 4.6.5 a 'Preferred procedure', but which has never been evaluated by NMIs, considering its very specific and constraining requirements

*Note 2 : Today, Gravimetric reference for tests => Type IV tanks => **2 days for this Test Program** (including facility installation, scale calibration, flushing and preparation for departure) , largely due to precautious defueling and cleaning of tanks after each tests (estimated around 1h30 per test)*

OIML R139-2 contents

section 4.6.6: Initial Verification of measuring system / Tests / "Alternative procedure" (where gas is not specified !)

Test #	Initial state
Test 4	Initial test receiver pressure of 0 kPa or higher if so required for safety reasons Initial station storage pressure at P_{st}
Test 5	Initial test receiver pressure of 0.5 P_v Initial station storage pressure at P_{st}

+

Ue $_{(k=2)}$ of reference < 1/3 MPE

#4,#5,#4,#5 –> 4 tests

Note : this test program could be much faster and should be considered for subsequent verification*

** Subsequent verification tests of a petrol dispenser = approx. 30 minutes ...*

Issue : Recommendation defines a theoretical maximum flow rate available in the refueling station and requires to reach 80% of this flow rate (stated in the Type approval certificate) during verification.

But experience shows that :

- **Conditions for verification are sometimes not relevant to reach 80% of max flow rate**
- **Theoretical flowrate on site is difficult to define (depending on architecture)**
- **Flowrate to be reached depends on the size of the testing capacity (type IV tanks)**

OIML R139-2 contents

section 5.2: Subsequent Verification of measuring system / Tests /

5.2	**Tests at subsequent verification**
5.2.1	Subsequent verification tests shall be carried out as specified in 4.6.

=> Regulation (when exists) can decide of a Test program among those defined for Initial Verification, i.e : § 4.6.5, § 4.6.6, § 4.6.7

+

Ue $_{(k=2)}$ of reference < 1/3 MPE

OIML R139:2018
Shortcomings

R139-1&2

Recommandation distinguishes 2 configurations with and without sequential control. Regarding experience with CNG this distinction which leads to distinguish type and verification tests should be rediscussed since :

there is no evidence of critical impact,

imposing sequential control makes controls more complicated to organize

R139-1 §5.4.(1&2) + R139-2 §3.5.2.1

The repeatability error of the meter and of the measuring system shall not exceed two thirds (2/3) of the applicable MPE. This requirement concerning repeatability shall be met durably, which shall be demonstrated during the type evaluation. Repeatability should be realized on test 4,5 and 6 (even test 6 cannot be performed with H2)

Template in R139-3 present repeatability evaluation on test 7 which is not requested

R139-1 §6.12.3.1.1

Printing of the customer's receipt is mandatory.

But in fact, agreement between two parts (BtoB) does not require a printing (record of the measurement seems to be enough).

R139-2 §4.5

Control of « printing device and type of paper » should be optional

Future dispensers will use less printings and paper.

Printing device and type of paper (R 139-1, 6.2.9.6); but the 6.2.9.6 does not exist. It probably refers to R139-1, 6.2.8.6

OIML R139 : CONCLUSION (1/3)

There is a clear need for revision of the OIML R139 for hydrogen application…

However, if some OIML P-Members asked for a revision in 2022 from OIML TC8/SC7 secretariat , the final decision was to reconduct the text as it is

Country (P-Members)	Reconfirm	Revise	Update
NL	X		
UK		X	
FR		X	
NO		X	
DK			X
JP	X		
AU	X		
CH		X	

NB : A request for revision shall be accepted when two-thirds of the votes cast by the P-members of the TC or SC are in favor

OIML R139 : CONCLUSION (2/3)

There is a clear need for revision of the OIMLR139 for hydrogen application…

The revision can be realized every 2 years – it should be at the beginning of 2024

TC 8/SC 7 Gas metering

BIML Contact

Mr Luis MUSSIO

Secretariat

NETHERLANDS
Dr Matthijs VAN DER WIEL

Participating Members (28)

AUSTRALIA	FRANCE	NORWAY	SOUTH AFRICA
AUSTRIA	GERMANY	P.R. CHINA	SPAIN
BELGIUM	INDIA	POLAND	SWEDEN
BRAZIL	IRAN	ROMANIA	SWITZERLAND
CANADA	JAPAN	RUSSIAN FEDERATION	TURKEY
CZECH REPUBLIC	KOREA (R.)	SERBIA	UNITED KINGDOM
DENMARK	NETHERLANDS	SLOVAKIA	UNITED STATES

OIML R139 : CONCLUSION (3/3)

There is a clear need for revision of the OIML R139 for hydrogen application…

We ask for an agreement for ALL involved parties to request a revision of OIML R139 to their national authorities by the end of the year/ beginning of 2024 and a harmonization of initial and subsequent verifications (see final talk of this workshop).

Bundesamt
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Vermessungswesen
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THANK YOU