

The 2nd Meeting of the informal working group on GTR No. 13 (Phase 2)

Activities Related to Hydrogen Storage Cylinders for FCV in P.R. China

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- 1. GB/T35544 Type 3 Hydrogen Storage Cylinders**
- 2. Test Methods for Material Compatibility**
- 3. Fatigue Tests of Used Type 4 Hydrogen Storage Cylinders**
- 4. Topics**

1. GB/T35544 Type 3 Hydrogen Storage Cylinders

- **GB/T 35544-2017 《Fully-wrapped carbon fiber reinforced cylinders with an aluminum liner for the on-board storage of compressed hydrogen as a fuel for land vehicles》**

Publication Date:2017-12-29

Implementation Date:2018-07-01

□ Scope

This standard contains requirements for the materials, design, manufacture, marking, and testing of serially produced, refillable type III cylinders intended only for the storage of compressed hydrogen gas for road vehicles. These cylinders:

- a) are to be permanently attached to the vehicle;
- b) have a capacity of **up to 450L water capacity**;
- c) have a nominal working pressure that does **not exceed 70 MPa**.

1. GB/T35544 Type 3 Hydrogen Storage Cylinders

□ Contents

(1) Scope

(2) Reference publications

(3) Terms, definitions and symbols

(4) Types, parameters, category and model

(5) Technical requirements

(6) Qualification tests

(7) Production and batch tests

(8) Marking, packing, transport and storage

(9) Product qualification certificate

- **Annex A (informative)** Non-destructive examination(NDE) defect size determination
- **Annex B (normative)** Design qualification tests for thermally activated pressure relief devices and valves

1. GB/T35544 Type 3 Hydrogen Storage Cylinders

□ Meet the requirements of UN GTR 13

ITEM	UN GTR 13	GB/T35544
Nominal working pressure	$\leq 70\text{MPa}$	✓
Service life	$\leq 15\text{years}$	✓
Design qualification tests for cylinder	Verification tests for baseline metrics	✓
	Verification test for performance durability (sequential hydraulic test)	✓
	Verification test for expected on-road performance (sequential pneumatic test)	✓
	Verification test for service terminating performance in fire	✓
TPRD qualification tests	Pressure cycling, accelerated life, temperature cycling, salt corrosion resistance, vehicle environment, stress corrosion cracking, drop and vibration, leak test, bench top activation, flow rate	✓
Check valve and shut off valve qualification tests	Hydrostatic strength, leak test, extreme temperature pressure cycling, salt corrosion resistance, vehicle environment, atmospheric exposure, electric test, vibration test, stress corrosion cracking, pre-cooled hydrogen exposure	✓

2. Test Methods for Material Compatibility

□ Material Test System at ZJU (HyMTS)



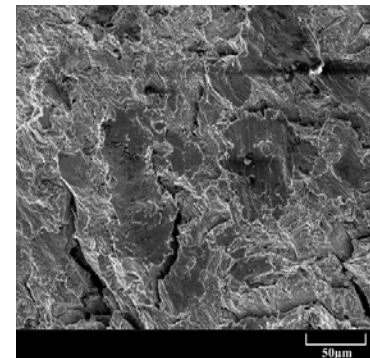
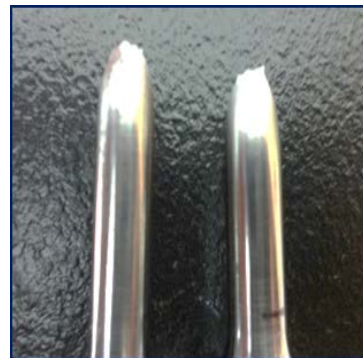
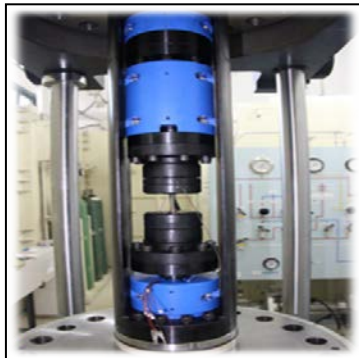
HyMTS-G1



HyMTS-G2

- ✓ Max pressure: **140MPa**
- ✓ Temperature : **-60°C ~ 100°C**
- ✓ Force: **120kN** (static)
100kN (dynamic)
- ✓ Tests:
 - **Fatigue Test**
 - **Slow Strain Rate tensile test**
 - **Fatigue crack growth rate test**
 - **Hydrogen assisted cracking threshold stress intensity factor test**

Materials tested include 4130X, X70, X80, S30408, 6061, 316L etc.



2. Test Methods for Material Compatibility

□ National Standards for Metallic Material Compatibility Test

- **GB/T 34542.2** : Test methods for evaluating metallic material compatibility in hydrogen atmosphere
 - ✓ Gain basic mechanical properties
 - ✓ Provide data for failure mechanism based design of components

- **GB/T 34542.3** : Test method for determination of the susceptibility of metallic materials to hydrogen gas embrittlement (HGE)
 - ✓ Quickly evaluate the susceptibility of metal to hydrogen embrittlement

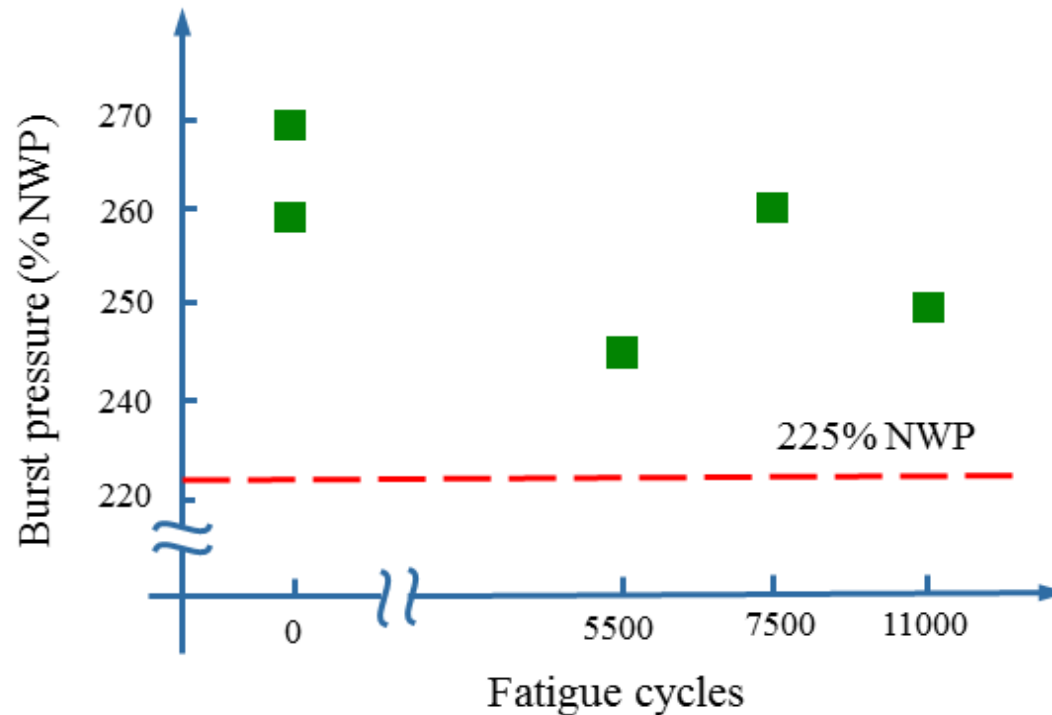
3. Fatigue Tests of Used Type IV Hydrogen Storage Cylinders

□ Results of residual burst strength test

Type IV Composite vessel	Actual service life (km)	Test method	Fatigue cycles	Burst pressure (MPa)	The ratio of BP/NWP
Vessel A	46607	Burst	0	180.6	2.58
Vessel B	46607	Burst	0	186.7	2.67
Vessel C	32073	Burst after fatigue	5500	171.0	2.44
Vessel D	32073	Burst after fatigue	7500	182.9	2.61
Vessel E	32073	Burst after fatigue	11000	174.1	2.49

3. Fatigue Tests of Used Type IV Hydrogen Storage Cylinders

□ Burst pressure at initial condition and end of service



- ✓ In order to lower the minimum burst pressure such as 200% NWP, **the relationship between burst pressure and fatigue life should be explored.**
- ✓ More reasonable indicators should be established to avoid over performance in either the burst strength or fatigue life.

4. Topics

- **Harmonization with ISO standard**
- **Develop methods for periodic inspection of the hydrogen storage cylinders**

4. Topics

□ UN GTR 13 and ISO/DIS 19881

- **UN GTR13** applies to all hydrogen fueled vehicles with a gross vehicle mass (GVM) of 4,536 kilograms or less, and all contracting countries should transfer UN GTR 13 into its national code and standard. It means that both type III container and type IV container used for such vehicle should meet the requirements of UN GTR 13.
- **ISO/DIS 19881** There are three categories of hydrogen container in ISO/DIS 19881 gaseous hydrogen-land vehicle fuel containers.
 - **Category A** containers are intended to be used in light duty and heavy duty land vehicle applications, regardless of the potential for further qualification to the UN GTR 13 for fuel cell vehicles.
 - **Category B** containers are **Type IV** designs of 70 MPa nominal working pressure and are intended to be further qualified in accordance with the UN GTR 13 for fuel cell vehicles with a gross vehicle mass of 4 536 kg or less.
 - **Category C** containers are containers that are intended to be used on hydrogen powered industrial trucks.

4. Topics

□ Change the definition of Category B ISO/DIS 19881

➤ **This means** that type III design of 70MPa nominal working pressure falls in category A, and only type IV container should meet the requirements in UN GTR 13. Category A and category B have different test methods in ISO/DIS 19881.

➤ **Proposal** Change the definition of Category B as follows:

Category B containers are **Type III and Type IV** designs of 70 MPa nominal working pressure and are intended to be further qualified in accordance with the UN GTR 13 for fuel cell vehicles with a gross vehicle mass of 4,536 kg or less.

We have already sent this comments to ISO/TC197 on 8 Sept.,2017

4. Topics

- **Develop methods for periodic inspection and testing of the hydrogen storage cylinders**
 - The existing standards related to the periodic inspections and testing of cylinders such as ISO 11623 and ISO 19078 don't contain the 70MPa on-board hydrogen storage cylinders.
 - Explore and develop methods for periodic inspection and testing of the 70MPa on-board hydrogen storage cylinders.

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Thanks for Your Attention!

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