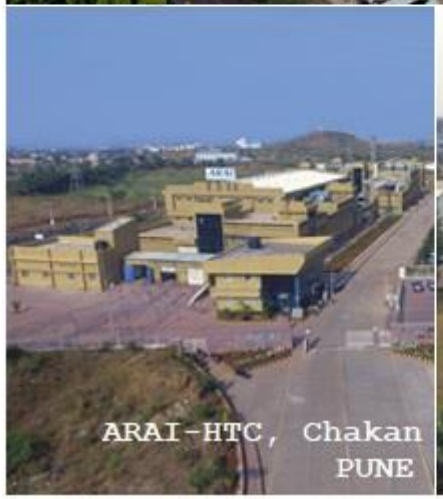
Standards and Regulations for Hydrogen

Dr. Sukrut Thipse
Sr. Deputy Director, ARAI

ARAI
Progress through Research

18-07-2023

ARAI ROLE IN ALTERNATIVE FUELS



- 01 R&D PROJECTS ON ALTERNATIVE FUELS
- 02 REGULATION FORMATION IN CMVR & BIS STANDARDS
- 03 CMVR CERTIFICATION VEHICLES ON ALTERNATIVE FUELS
- 04 TRAINING & IPR GENERATION ON ALTERNATIVE FUELS
- 05 CONSULTANCY TO INDUSTRY

ARAI Role in Hydrogen Program

MEMBER OF MNRE COMITTEE

ARAI was member of Committee chaired by Dr. K Kasturirangan & Prepared detail project report on IPR

COE IN H_2 TECH

ARAI was identified as 'Center of Excellence' on Hydrogen Technology under MNRE scheme

HCNG BLENDS

ARAI initated work on Engines using Hydrogen-CNG blends from 2010

FUEL CELL

ARAI is also working in the area of fuel cell technology & has initiated program for H_2ICE

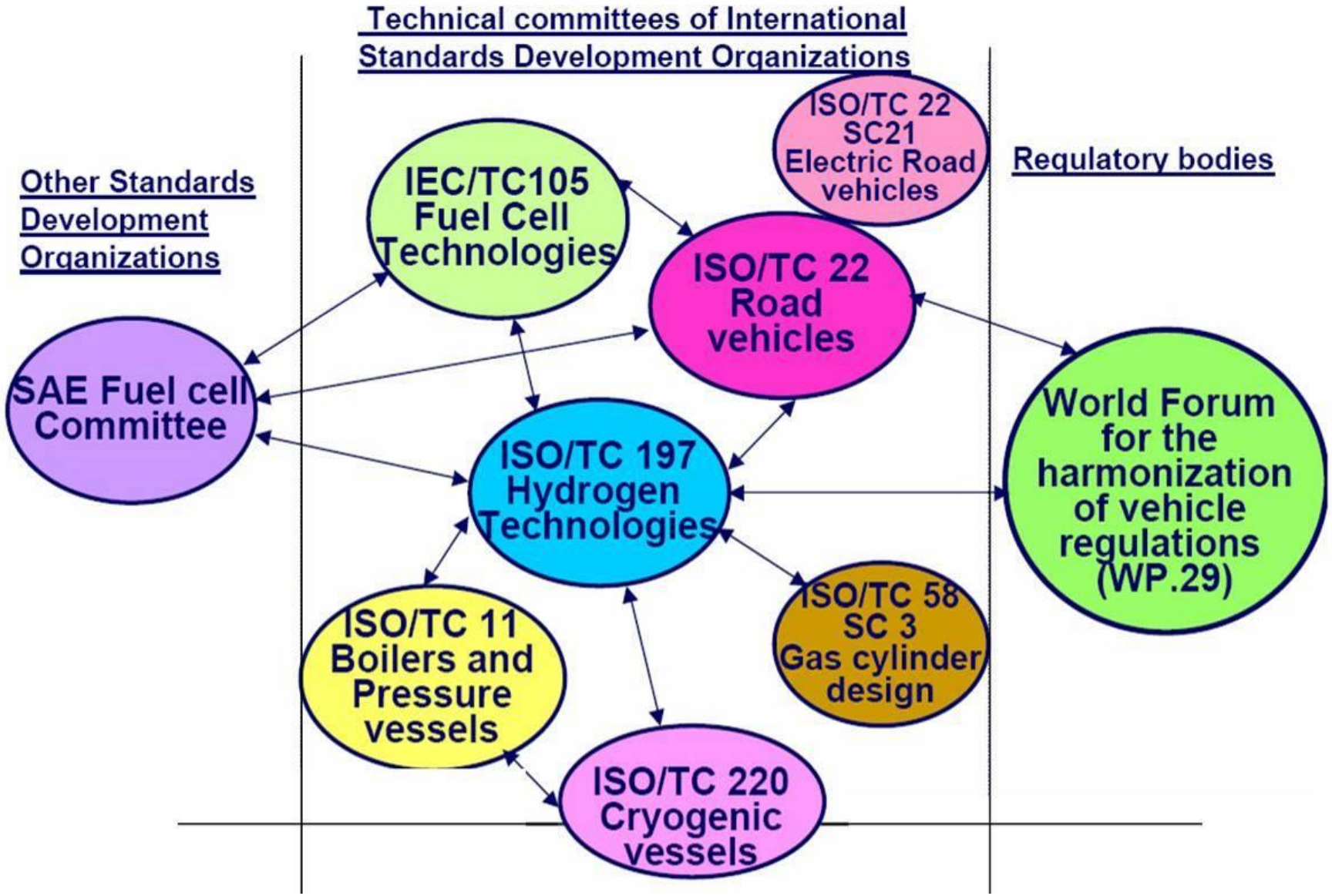
STANDARDS & REGULATIONS

ARAI is responsible for development of regulations & standards for Hydrogen

FACILITIES

Facilities for development and certification for Hydrogen Engines is under development at ARAI

International Standardization Bodies



Regulations for Hydrogen

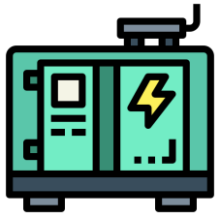
Regulations

- Fuel

- Storage & Dispensers

- Applications
  - Automotive

  - Genset



  - Off-Highway

International Regulations for Hydrogen Applications

Economic Commission for Europe – ECE

- UN ECE 146
  Hydrogen and Fuel Cell 2&3 wheelers
- UN ECE 134
  Hydrogen and Fuel Cell Vehicles (HFCV)
- EU 2021/535
  LHSS and CHSS Storage systems

Global Technical Regulations (GTR)

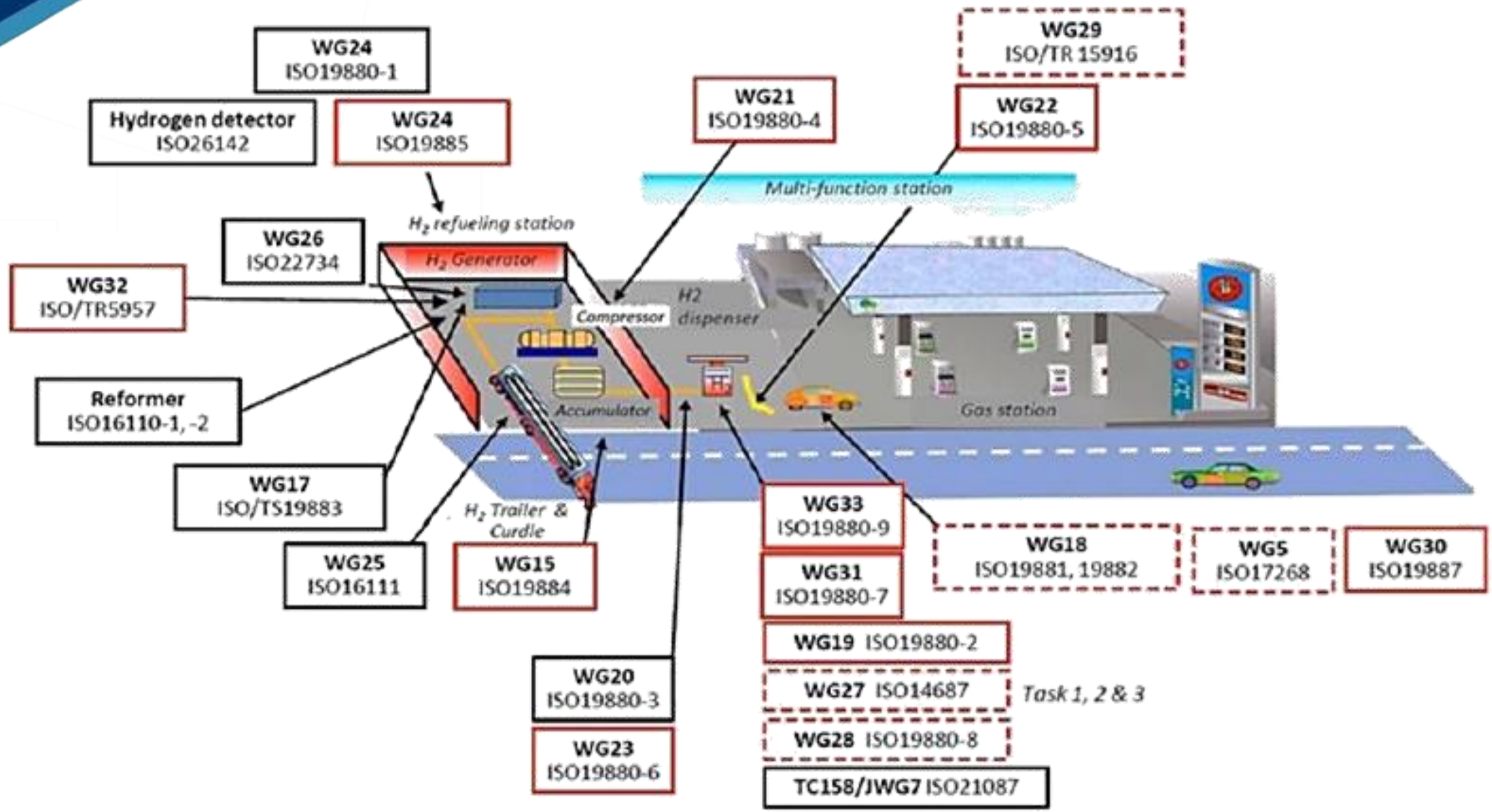
- GTR 13
  Hydrogen and Fuel Cell Vehicles (HFCV)

Regulation (EU) 2021/535:

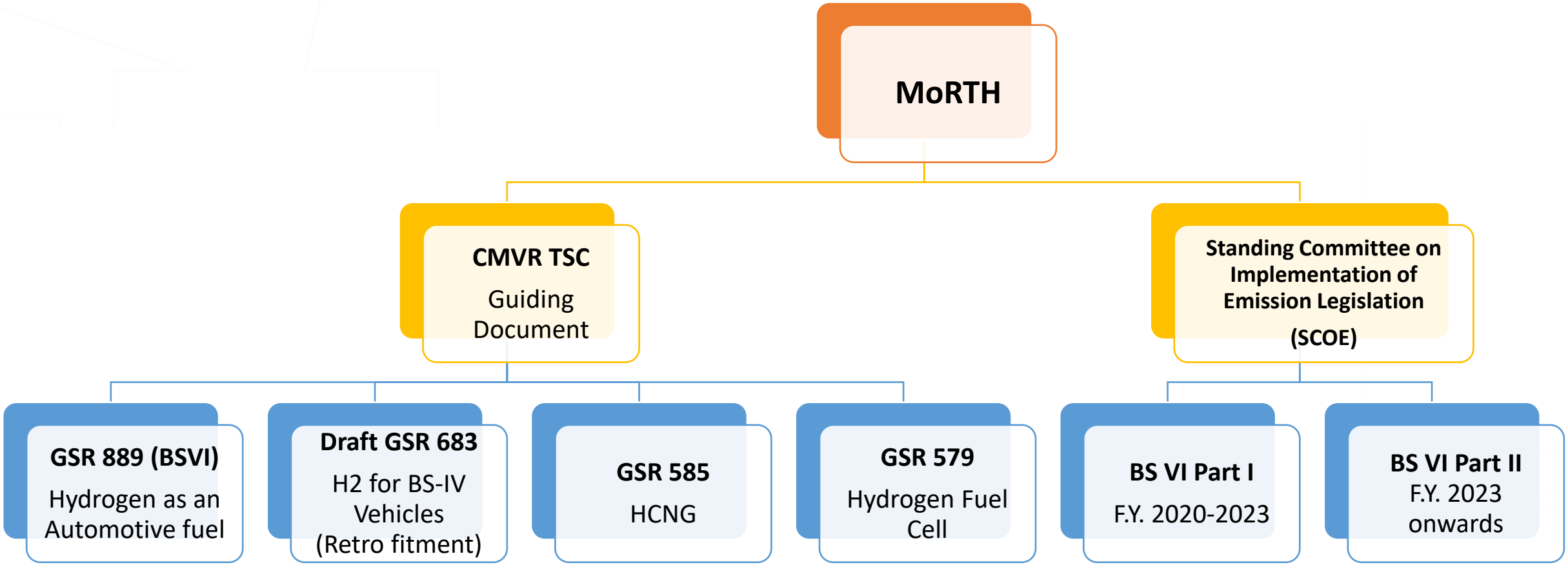
a) The liquefied hydrogen storage systems (LHSS), including their containers, pressure relief and shut-off devices, with respect to their safety performance and material compatibility. * LHSS are restricted to pilot test vehicles.

a) The compressed hydrogen storage systems (CHSS), including their containers and primary closing devices, comprising TPRD, check valve and automatic shut-off valves, with respect to their material compatibility.

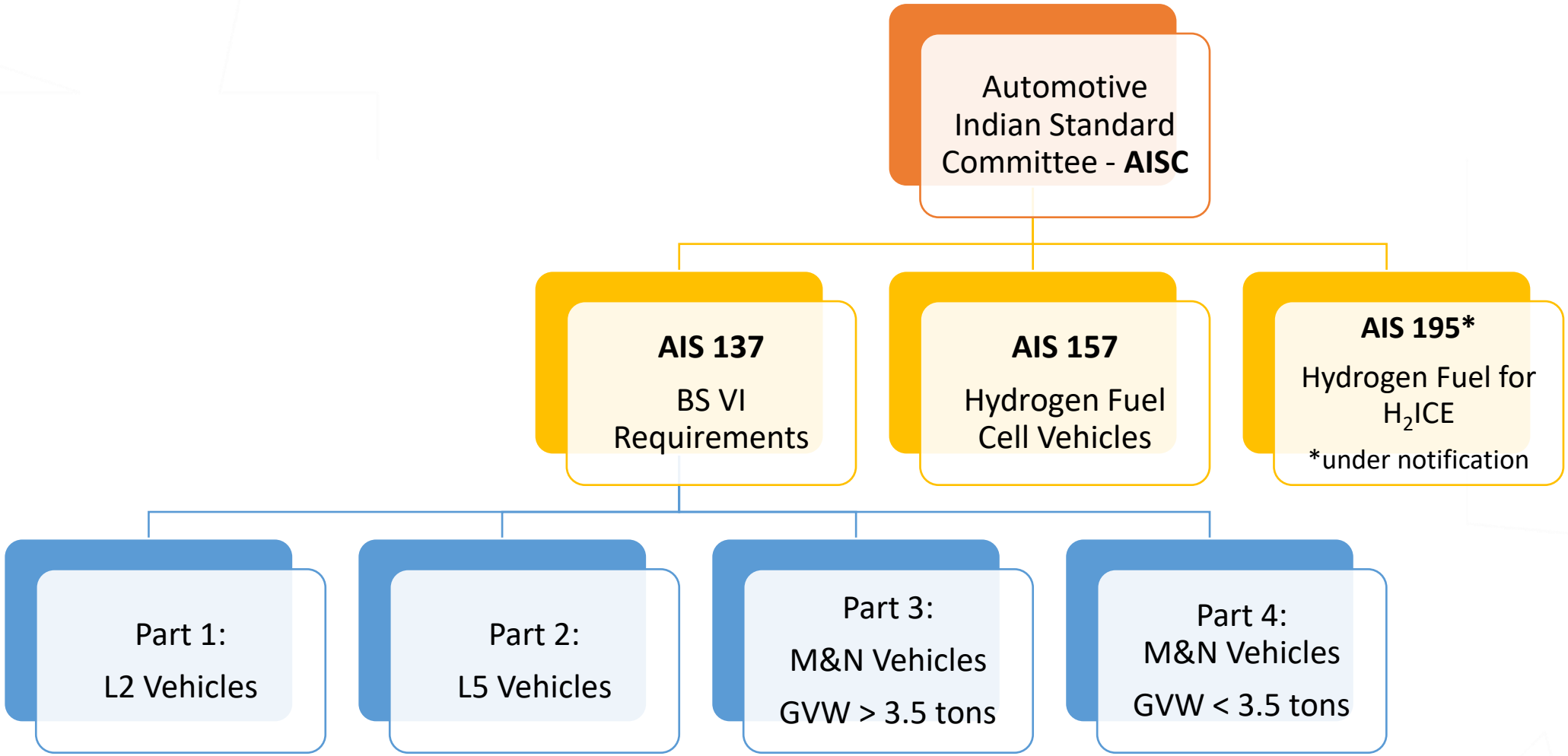
ISO / TC 197 Standard for Hydrogen Fuel



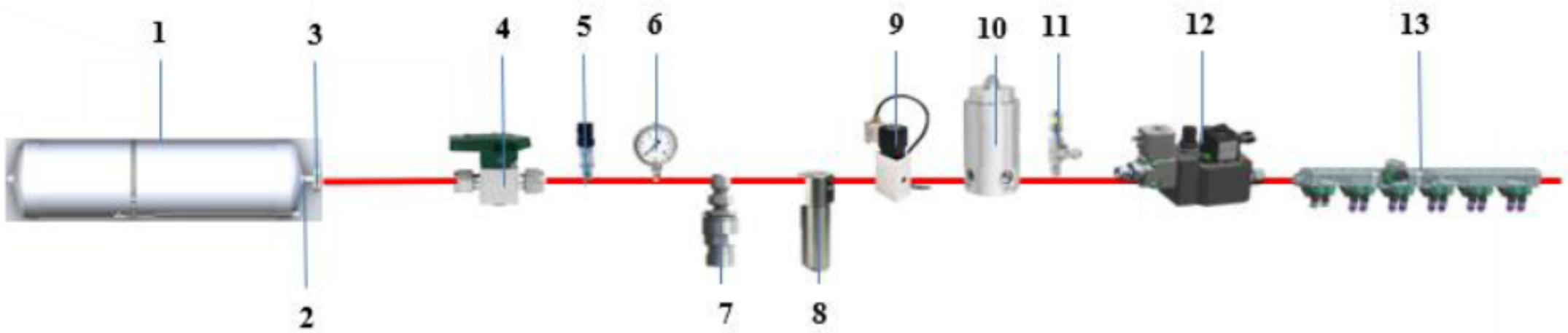
Automotive Regulations for Hydrogen Fuel



Indian Regulations for Hydrogen Applications



H2 Fuel System Components as per AIS 195



1. Tank
2. PRD vent
3. Cylinder valve
4. Shut off valve
5. Pressure transducer
6. Pressure gauge
7. Receptacle
8. Filter
9. Solenoid valve
10. HP regulator
11. PRV vent
12. LP regulator
13. Injector rail assembly

Summary of AIS 195

Clause No.	Details
1.0	Scope
2.0	Reference Standards
3.0	Definitions
4.0	Schematic representation of Compressed gaseous hydrogen vehicle
5.0	Part I - Specifications of Compressed gaseous hydrogen storage system
6.0	Part II – Specifications of specific components for compressed gaseous hydrogen storage system
7.0	Part III – Specifications of a vehicle fuel system incorporating the compressed gaseous hydrogen storage system

Annexure-IA	Typical representation of compressed gaseous hydrogen vehicle
Annexure-IB	Typical Profile of Hydrogen Fuelling Receptacle
Annexure-II	Test procedures for the compressed gaseous hydrogen storage system
Annexure-III	Test procedures for specific components for the compressed gaseous hydrogen storage system
Annexure-IV	Test procedures for a vehicle fuel system incorporating the compressed gaseous hydrogen storage system
Annexure-V	Vehicle Identification Requirements (Compressed gaseous hydrogen)
Annexure-VI	Approval testing for compressed gaseous hydrogen storage system (CHSS) modifications
Annexure-VII	Technical Specification of Hydrogen Powered Vehicles To Be Submitted By Vehicle Manufacturer
Annexure-VIII	Typical Liquefied Hydrogen Storage System (LHSS)
Annexure IX	Reference Standards
Annexure X	AISC Panel Composition
Annexure XI	Automotive Industry Standards Committee Composition

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Hydrogen Fuel Cell Standard (AIS-157)

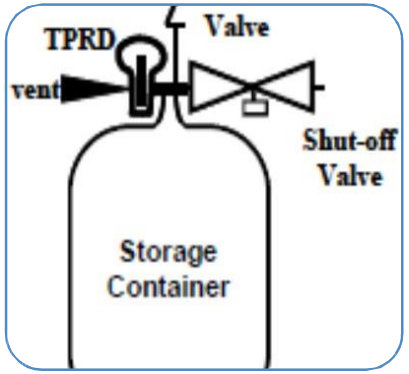
Reference to various standards to cover various aspects of hydrogen fuel cell vehicles is given in AIS 157

H2 Receptacles & Nozzles

ISO 17268
Refueling Connection Devices

ISO 15916
Hydrogen Safety

WP2 Hy Approval
Refueling Station Approval



H2 Storage System

ISO 19881
H2 Cylinders

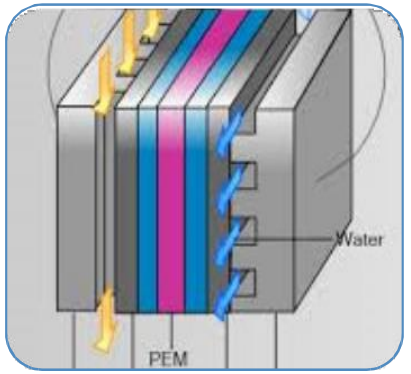
ISO 12619
Cylinder valves & Fittings

EC 79/2009
Installation Safety

H2 Fuel System Components

ISO 12619
H2 Fuel Components

EC 79/2009
Installation Safety

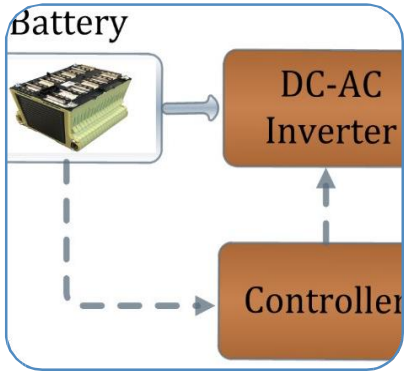


Fuel Cell System

GTR 13
H2 Fuel Cell Vehicles

UN ECE R134
Hydrogen Fueled Vehicles

ISO 27273
Functional Safety



Electric Propulsion

AIS-038(Rev.1)
Safety

AIS-039(Rev.1)
Energy Consumption

AIS-041(Rev.1)
Power Measurement

AIS-048(Rev.1)
Traction Battery

AIS-049(Rev.1)
Type Approval Process

Hydrogen Fuel Notified for Gensets in CPCB IV+

Emission limits for Genset engines up to 800 kW Gross Mechanical Powered by
1) All CI engines and 2) PI engines > 800 cc engine displacement

Power Category, kW	NOx	HC*/**	NOx +HC*/**	CO	PM		Smoke (light absorption coefficient)	
	CI/PI	CI/PI	CI/PI	CI/PI	CI	PI	CI	PI
	g/kWh						m^{-1}	
P ≤ 8	-	-	7.5	3.5	0.30	-	0.7	-
8 < P ≤ 19	-	-	4.7	3.5	0.30	-	0.7	-
19 < P ≤ 56	-	-	4.7	3.5	0.03		0.7	
56 < P ≤ 560	0.40	0.19	-	3.5	0.02	-	0.7	-
560 <P ≤ 800	0.67	0.19	-	3.5	0.03	-	0.7	-

Emission limits for portable Genset up to 19 kW powered by PI engines (up to 800 cc engine displacement)

	Category Engine Displacement (cc)	CO	NOx +HC */**
		g/kWh	
Class -1 >	Up to 99	< 250	< 10
Class -2 >	> 99 and up to 225	< 250	<08
Class -3 >	> 225 and upto 800	< 250	< 06

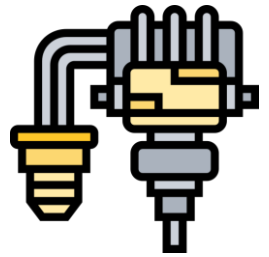
Hydrogen Fuel Notified for Gensets in CPCB IV+

Sr. No.	Fuel	Applicable Standard
1	Natural Gas	Annexure IV - L - CMVR Refer rule 115 H
2	Bio methane	IS 16087: 2016
3	LPG	IS 14861 : 2000 (REAFFIRMED 2020)
4	E10	IS 2796: 2017
5	E12	IS 17586: 2021
6	E15	IS 17586: 2021
7	E20	IS 17021: 2018
8	E85	IS 16634: 2017
9	E100	IS 15464: 2004
10	ED95	Is 16629: 2017
11	M15	IS 17076: 2019
12	M85	Annexure ZB - CMVR Refer rule 115 H
13	M100	IS 17075 : 2019
14	MD 95	Annexure ZA - CMVR Refer rule 115 H
15	DME	IS 16704: 2018
16	Hydrogen	IS 16061: 2021
17	Hydrogen blended with CNG (18% hydrogen)	IS 17314: 2019
18	Bio-Diesel (B7)	IS 1460 : 2017
19	Bio-diesel (B8 to B20)	IS 16531: 2022
20	Bio-diesel (B100)	IS 15607 : 2022

Standards for Hydrogen

Standards

- Fuel
- Fuel System Components
- Storage
- Dispensers



Standards for Hydrogen Fuel

HYDROGEN FUEL QUALITY PRODUCT SPECIFICATION

Characteristics	ISO 14687-2:2012
Hydrogen fuel index	**> 99.97%**
Total non-hydrogen gases	**< 300**
Max concentration of individual contaminants	
Water (H_2O)	**< 5**
Total hydrocarbons (Methane)	**< 2**
Oxygen (O_2)	**< 5**
Helium (He)	**< 300**
Nitrogen (N_2) and Argon (Ar)	**< 100**
Carbon dioxide (CO_2)	**< 2**
Carbon monoxide (CO)	**< 0.2**
Total sulphur compounds (H_2S)	**< 0.004**
Formaldehyde (HCHO)	**< 0.01**
Formic acid (HCOOH)	**< 0.2**
Ammonia (NH_3)	**< 0.1**
Total halogenated compounds	**< 0.05**
Maximum particulate concentration	**< 1 mg/kg**

IS 16061 : 2021 /
ISO 14687:2019

Additional standard for fuel quality for relaxed fuel quality related to H_2ICE is under development

Indian Standard for Hydrogen Fuel System Components – BIS TED 26

Sr. No.	Component / Vehicle Test	As per Standard	Applicability as per	
			AIS-157 (HFCEV)	Draft AIS-195 (HICEV)
1	Hydrogen fuelling receptacle	ISO 17268	Yes	Yes
2	Compressed gaseous hydrogen cylinder	ISO 19881:2019, UN R 134, GTR 13 (Major test requirements of ISO 19881:2019 are reproduced in UN ECE R 134 & draft AIS-195)	Yes	Yes
3	Automatic shut-off valve	ISO 12619-6	Yes	Yes
4	Crash Safety requirements for cars (or) fitment of SUPD/protective devices	as per CMVR	Yes	Yes
5	Pressure Relief Device (PRD / TPRD)	IS/ISO 12619-10 or UN R 134	Yes	Yes
6	Pressure Relief valve (PRV)	IS/ISO 12619-9	Yes	Yes
7	Rigid Fuel Lines	IS/ISO 12619-13	Yes	Yes
8	Flexible Fuel Lines	IS/ISO 12619-14	Yes	Yes
9	Gas tight housing & Ventilation hoses	IS/ISO 12619-12	Yes	Yes

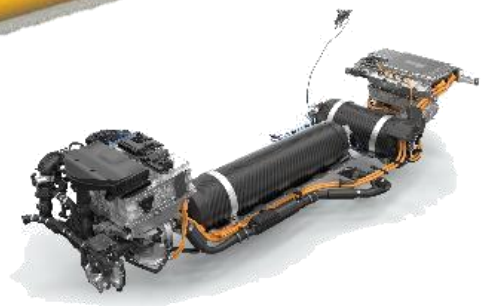
Indian Standard for Hydrogen Fuel System Components

Sr. No.	Component / Vehicle Test	As per Standard	Applicability as per	
			AIS-157 (HFCEV)	Draft AIS-195 (HICEV)
10	Fittings	IS/ISO 12619	Yes	Yes
11	Manual cylinder valve, Pressure regulator, Pressure indicator, Excess flow valve, Filters, Pressure/Temperature/Hydrogen/Flow sensors and hydrogen leakage detection sensors	IS/ISO 12619	Yes	Yes
12	Protection against flammable conditions: Single failure conditions	Annexure 5, para 3.2 of UN R134. Procedure reproduced in D-AIS-195.	Yes	Yes
13	Requirements for electric propulsion and power management system	As per CMVR	Yes	No
14	Hydrogen Fuel consumption measurement	IS/ISO 23828	Yes	Yes

Storage Regulations for Hydrogen Fuel

Petroleum & Explosives Safety Organization (PESO)
(nodal agency for Fuel storage regulations)

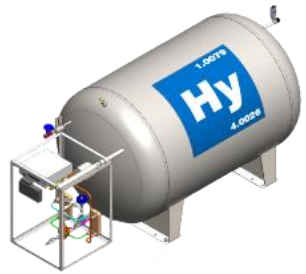
On-Board Storage



Gas Cylinder Rules 2016

Non-Bulk Storage i.e., Gas Cylinders- Gas Cylinder Rules, 2016 Stipulates the safety guidelines for the storage and transport of any permanent gas, liquefied gases or gas mixture in a closed gas cylinder exercising a pressure either exceeding 2.5 kgf/cm^2 absolute (1.5 kgf/cm^2 gauge) at 15^{0}C

Storage Vessels



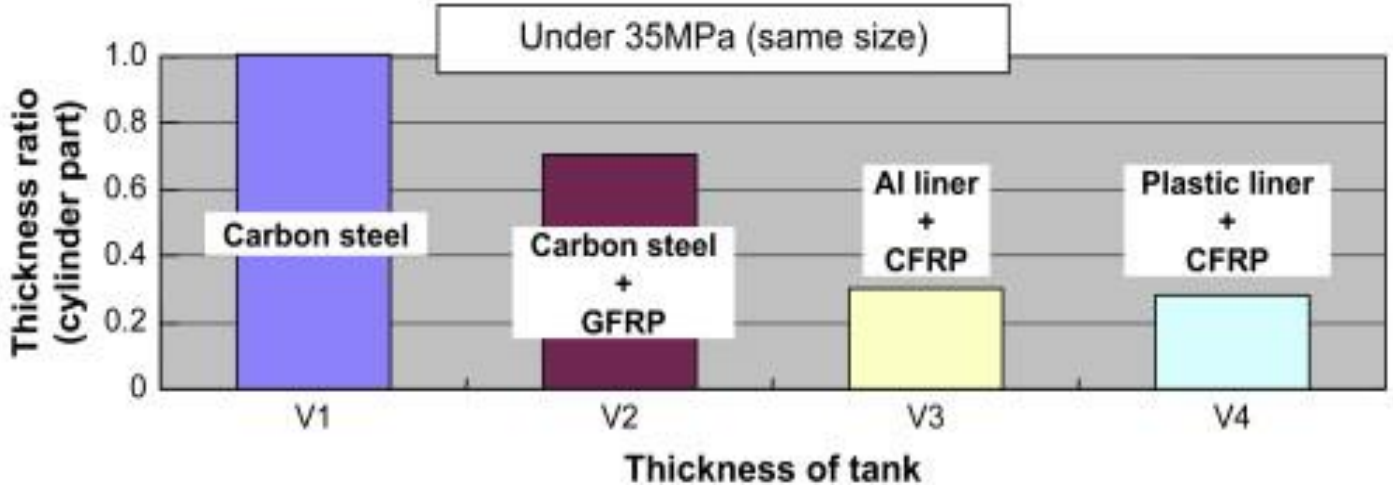
Static and Mobile Pressure Vessels (Unfired) Rules 2016

Bulk Storage i.e., Pressure Vessels – SMPV Rules, 1981 Stipulates the safety guidelines for the storage and transport of compressed and liquefied gases filled in pressure vessels exceeding 1000 liters capacity exercising pressure exceeding 1.0 atmosphere (gauge) at maximum working temperature (55^{0}C)

Standards for Hydrogen Cylinders

IS 16735 : 2018 - Cylinders for On-board Storage of Compressed Gaseous Hydrogen and Hydrogen Blends as a fuel for Automotive Vehicles

	V1	V2	V3	V4
composition	 All Metal	 Metal Liner + GFRP layer (hoop lap)	 Metal Liner + CFRP layer (full lap)	 Plastic Liner + CFRP layer (full lap)



HYDROGEN FUEL STATIONS

Hydrogen fuel stations are to be considered as subject to a particular risk of fire and explosion. The degree of risk influences the type of electrical installation.

In particular ATEX Directive must be considered for this application.

Directive 99/92 EC ATEX 137A

Directive 94/9/EC ATEX 100

i. NFPA 52 – Vehicular fueling system

ii. NFPA 55 – Storage use & handling of compressed gases

iii. NFPA 496 – Standard for purged & pressurized enclosures

iv. NFPA 497 / IS: 5572 – Hazardous electrical classification

v. Electrical – IEC / NEC (NFPA 70)

vi. Dispenser – API/SAE

vii. Storage Tanks and Piping – ASME Code

Standards for Hydrogen Dispensers

ISO 19880-1:2020

Gaseous hydrogen — Fuelling stations

J2601

Fuelling station dispenser type

Oil Industry Safety Directorate

(OISD) Standard for Dispensers

Hydrogen-CNG (HCNG) – Technology Applicable for Vehicles

For India, the HCNG technology is best feasible for SI engines for Buses

Buses

- HCNG is the general term used to denote varying blends of Hydrogen and CNG and is considered as a transition fuel towards Hydrogen
- The name “Hythane®” signifies a 20 % blend of Hydrogen and Methane (CNG) by volume patented by Frank Lynch of Hydrogen Consultants Inc, USA
- HCNG has advantage of low minimum ignition energy and wide range of flammability limits
- Adding Hydrogen, which has higher flame speed to a low flame speed fuel like CNG, improves the combustion efficiency of the HCNG blend
- HC and CO emissions are lower by 30% for HCNG as compared to CNG. NOx emissions are reduced by adding Hydrogen to CNG.
- HCNG can use existing CNG Infrastructure

HCNG IS THUS THE FIRST STEP FOR INTRODUCING HYDROGEN AS AN AUTOMOTIVE FUEL

Hydrogen-CNG (HCNG) Pilot Project in Dellhi

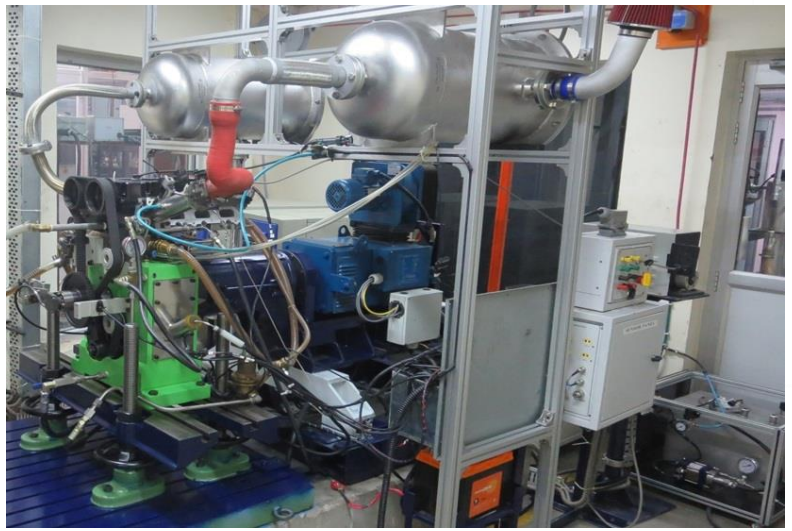
Delhi Transport Minister Kailash Gahlot on 20th October 2020 inaugurated HCNG Plant and Dispensing Station at Rajghat Depot. The 4 Ton/day Compact reformer- based HCNG production Plant has been set-up by IOCL in collaboration with Transport Department of Delhi. 40 Buses are now run on HCNG

Ministries Engaged in Hydrogen Program in India

- Ministry of New & Renewable Energy (MNRE)
- Ministry of Petroleum & Natural Gas (MoP&NG)
- Ministry of Road Transport & Highways (MoRT&H)

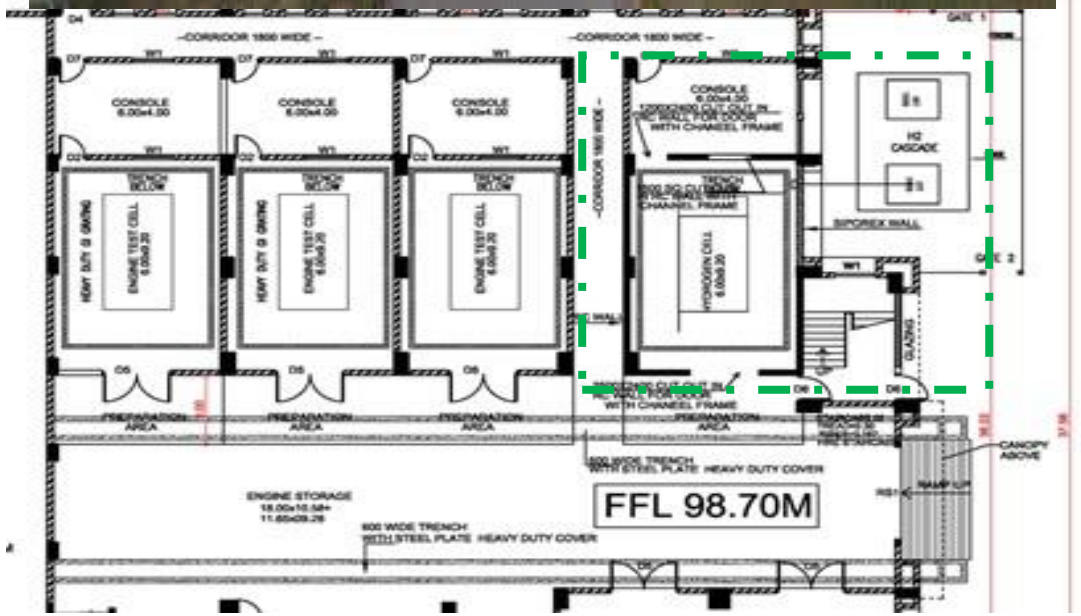
Hydrogen Test Facilities @ ARAI

- Augmentation of facilities at ARAI for automotive certification of hydrogen IC engine, Hydrogen-CNG and hydrogen fuel cell vehicles is in progress.
- Facilities for hydrogen cylinder testing are proposed in a new greenfield facility.
- ARAI provides regulatory and standard development support to enable introduction of hydrogen mobility in India.



Project was identified as one of the seven mission mode projects in the MNRE Hydrogen Committee chaired by eminent scientist Shri. Kasturirangan

Hydrogen Test Facilities @ ARAI



Hydrogen Test Cell has been constructed at ARAI HTC, Chakan with following Features

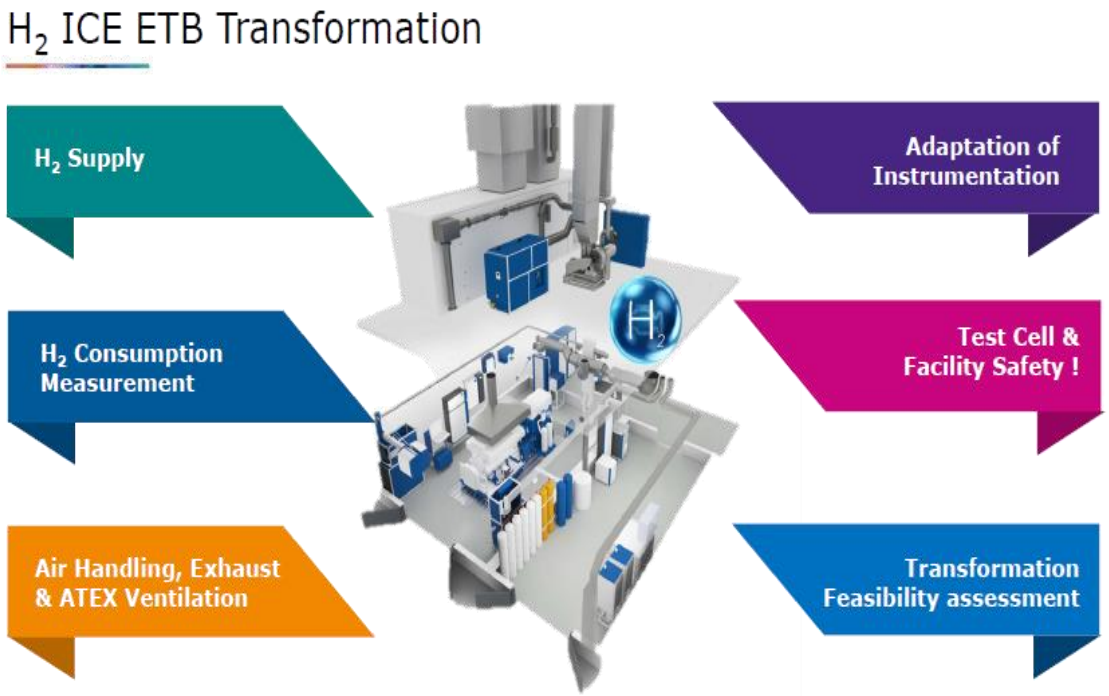
- Sloping roof for venting hydrogen
- Isolation from other test cells
- Weak wall for Hydrogen impact
- Area for Storage of hydrogen cascades outside test cell area

Hydrogen Test Cell is located at Green Mobility Building at HTC.

Proposed Test Facilities – Technical Information

Hydrogen IC Engine Test Cell

- 350 kW dynamometer with all engine data acquisition and control
- Mechanical system and engine instrumentation equipment
- Consumption equipment and conditioning Systems
- Emission measurement system (Pre-post), PM PN, FTIR, H2 analyser for H_2 compatibility
- Intake and exhaust Air handling system
- H2 storage & distribution
- Air Handling & exhaust system – ATEX certified
- Test cell air conditioning and HVAC system
- Safety requirement for H2 test cell
- Hydrogen Cascade



Source: AVL

Summary

- Hydrogen and other gaseous fuels are promising energy source for pollution reduction.
- Indian regulations are being continuously upgraded - Performance and safety aspects are given equal importance
- Development of R &D and certification facilities is the key for success of Hydrogen ICE and Fuel cell program in India.
- Emphasis to be given Training for awareness to concerned stake holders.
- The real challenge ahead is to ensure the best safety practices and continuous up gradation of technology in the coming years

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