Hydrogen Storage in Road Vehicles -

Regulations in Japan and Standards in the U.S.

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StorHy final Event

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Topics

Japanese Hydrogen Storage Regulations

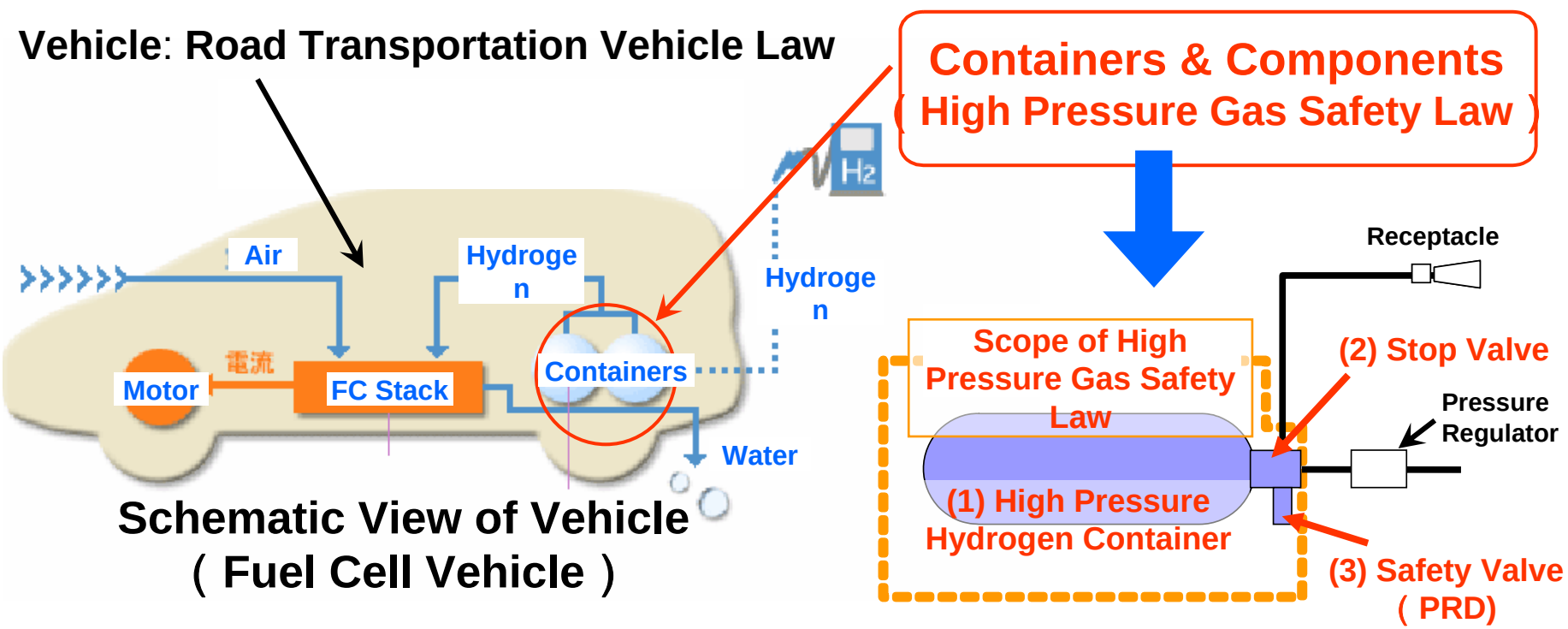
- Scope
- Content
- Outlook

U.S. Hydrogen Storage Standard (SAE J2579)

- General Structure
- Guiding Principles
- Compressed Hydrogen Performance Requirements

Summary

Scope of Regulations in Japan



Regulation:

(1) High Pressure Hydrogen Containers → JARI S 001

(2) Stop Valve & (3) Safety Valve (PRD) → JARI S 002

Current Standards Situation in Japan

- **Current Japanese Technical Standards (JARI S 001 & S 002) have already been applied as regulations since March 2005.**

JARI S 001(2004)

Technical Standards for Containers for Compressed-Hydrogen Vehicle Fuel Device

JARI S 002(2004)

Technical Standards for Components (valve and PRD) for Compressed-Hydrogen Vehicle Fuel Device

Outline of Technical Standard JARI S001

Scope	**VH3-Container and VH4-Container are permitted**
Minimum rupture pressure	**Stress ratio : 2.25**
Materials	**SUS316L, A6061T6**
Container Inspection	**Maximum filling pressure shall be 35 MPa or less**
	Internal cubic capacity shall be 360L or less
Room Temperature Pressure Cycle Test	**The test shall be carried out by shuttling between pressure of up to 2 MPa and pressure equal to or greater than 125% of the maximum filling pressure**
Bonfire Test in Design Confirmation Test	**The gas filled into the container shall be hydrogen gas**
Gas Permeation Test in Design Confirmation Test	**The rate of hydrogen gas permeation is less than 2 cm3 per hour per liter of container internal cubic capacity**
Hydrogen Gas Cycle Test	**pressure shall be added at least 1,000 times**

Necessity of Japanese Standards Revision

JARI S 001 & S 002 are standards for initial introduction of FCVs to the market.
But it is necessary to consider the revision for future mass production of FCVs.

1) Light-weight and Low-cost high-pressure hydrogen containers and components are necessary.

2) Expansion of designated materials is necessary.
(In Japanese case, the current standards limit the materials that can be used in high-pressure hydrogen environment)

3) Finally standardization of material evaluation methods is necessary.

Concepts of New Standard for Containers

1) To change the maximum working pressure from 35MPa to 70MPa.

2) To consider the Vehicle usage, Lifetime, Load conditions and Prospective Performance.

a) To change the pressure cycling test condition reflected the FCV cruising distance as a result of prospective performance and lifetime.

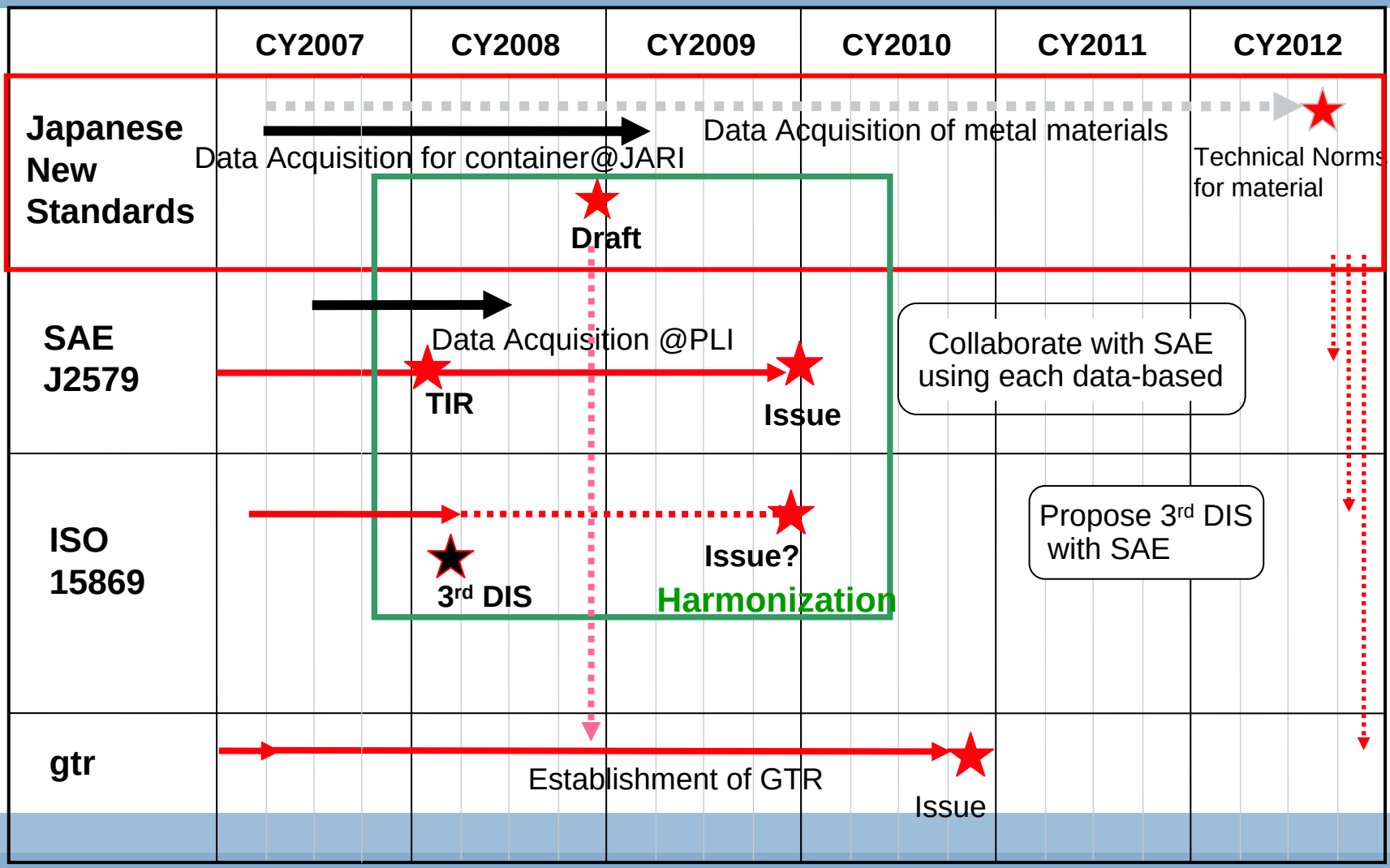
b) To change the extreme temperature cycling test condition reflected actual low and high temperature (under high speed hydrogen supply and fast filling).

3) To guarantee the Container strength after Durability tests reflected Vehicle usage and Lifetime.

a) To change the cycle numbers and condition of burst pressure test.

b) To execute the sequential loading tests.

Draft Schedule for International Harmonization



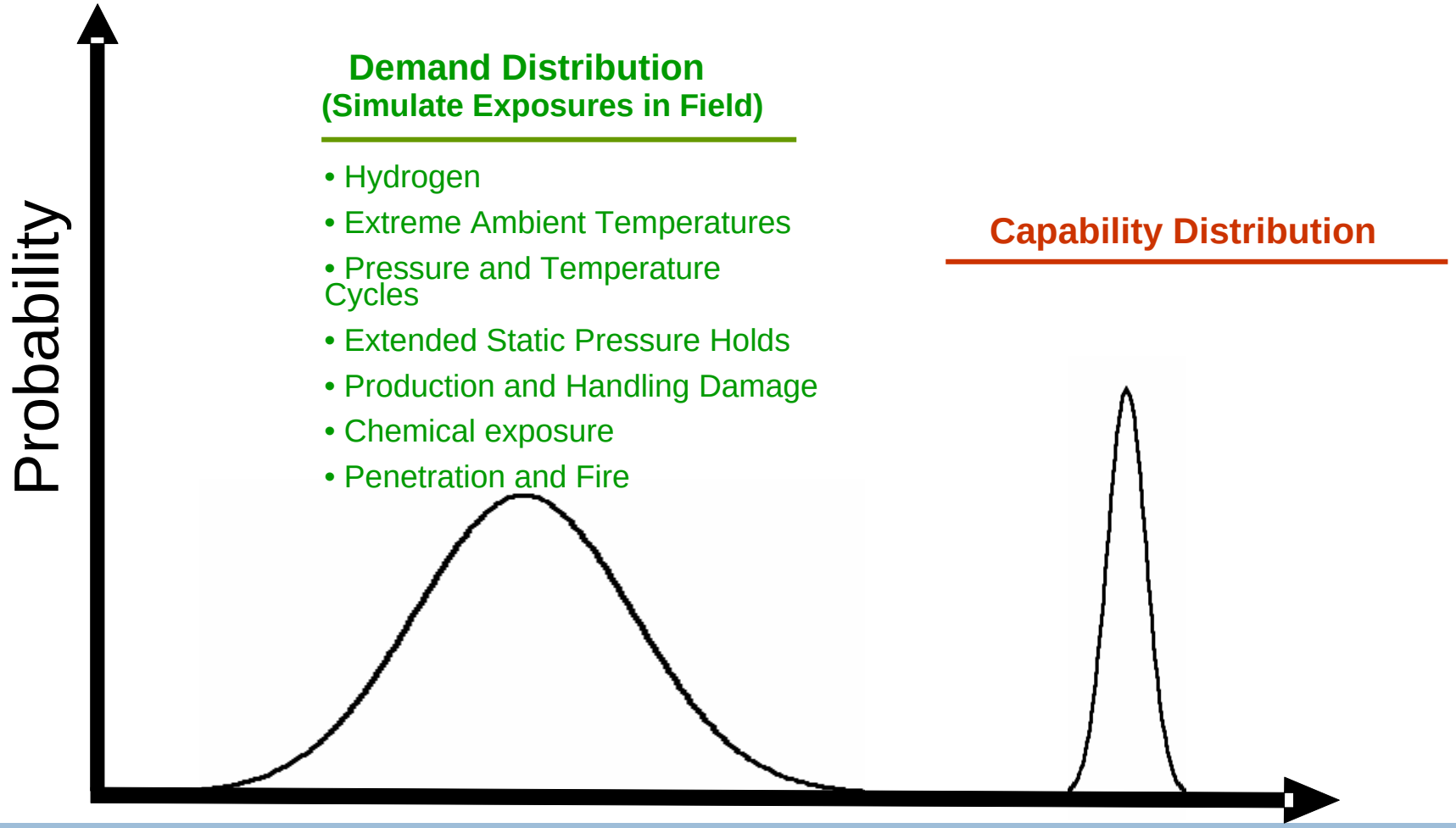
SAE J2579 Technical Information Report

Fuel Systems in Fuel Cell & Other Hydrogen Vehicles

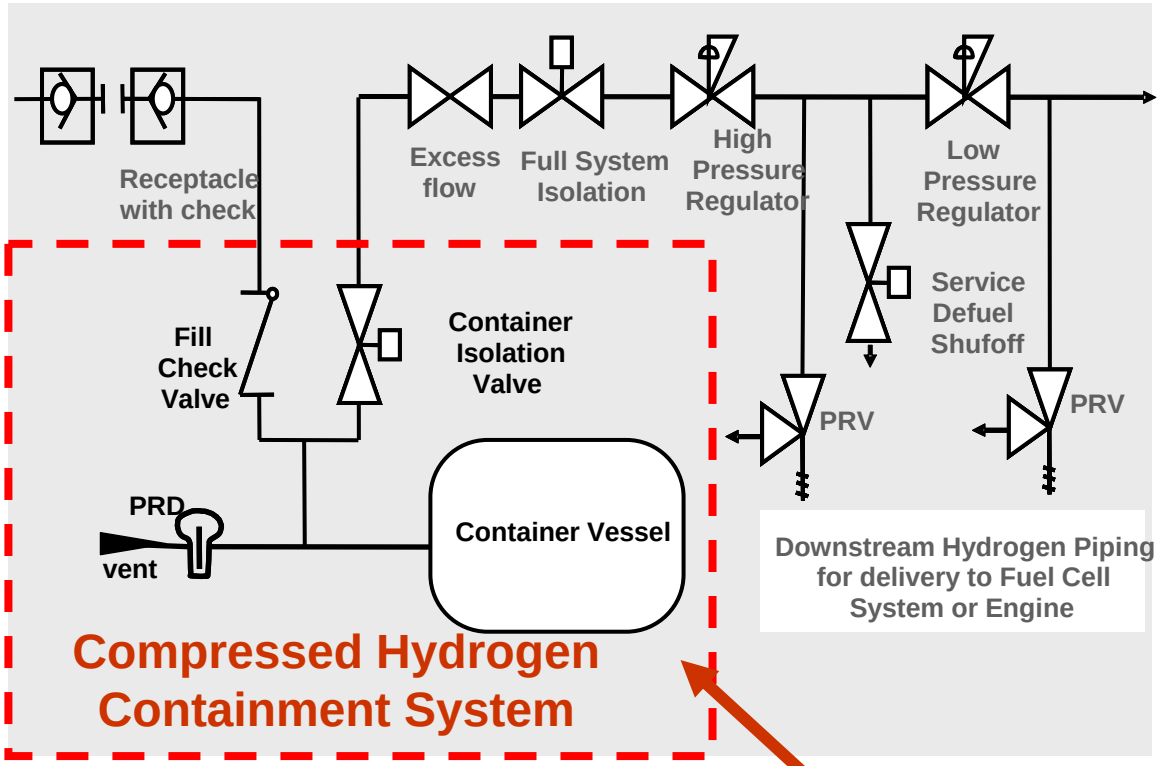
Background

- Work on motor vehicle hydrogen storage system code initiated in SAE Fuel Cell Safety Work Group in 2003.
- Active participation by fuel cell vehicle and storage system manufacturers and testing organizations, including representation from Asia, Europe and North America.
- Existing codes including NGV2, EIHP, FMVSS 304 and CSA B51 considered, with focus to develop design-independent performance-based code.
- SAE J2579 balloted in late 2007 and published as Technical Information Report (TIR) in January 2008.
- Two-year period for evaluation testing and workplan items with goal to publish SAE J2579 as Recommended Practice in early 2010.

Verification of Compressed Hydrogen Storage System Performance



Typical Compressed Hydrogen System



Includes all components and parts that form the primary pressure boundary for stored hydrogen

Isolates stored hydrogen from --

- **the remainder of the fuel system**
- **the surrounding environment**

Principle of “Design for Safety”

No single-point failure should cause unreasonable risk to safety or uncontrolled vehicle behavior:

- Fail-safe design
- Isolation and separation of hazards to minimize cascading of events
- Fault management with staged warnings and shutdowns

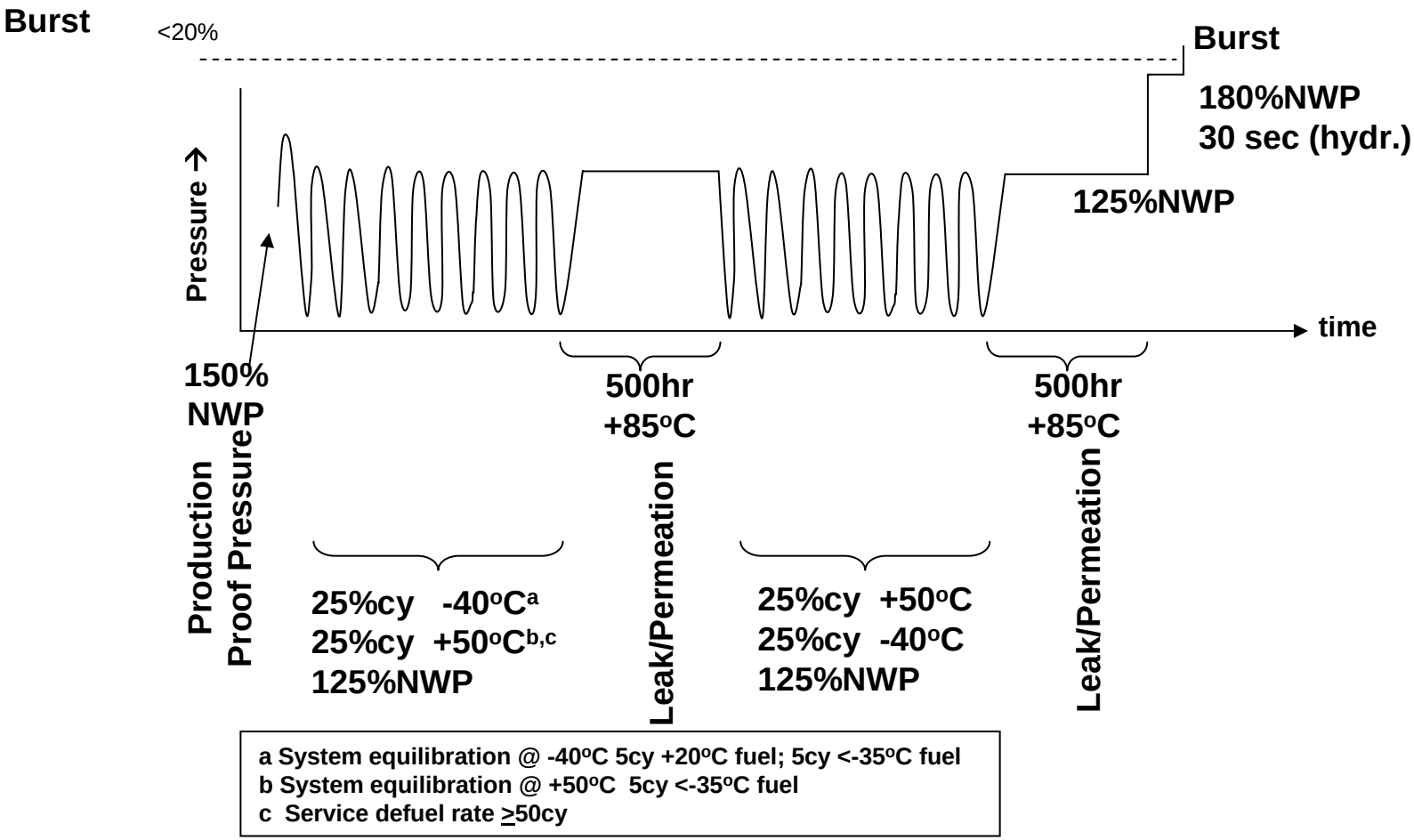
Isolation and containment of stored hydrogen is required to practice fault management on hydrogen and fuel cell vehicles.

Content

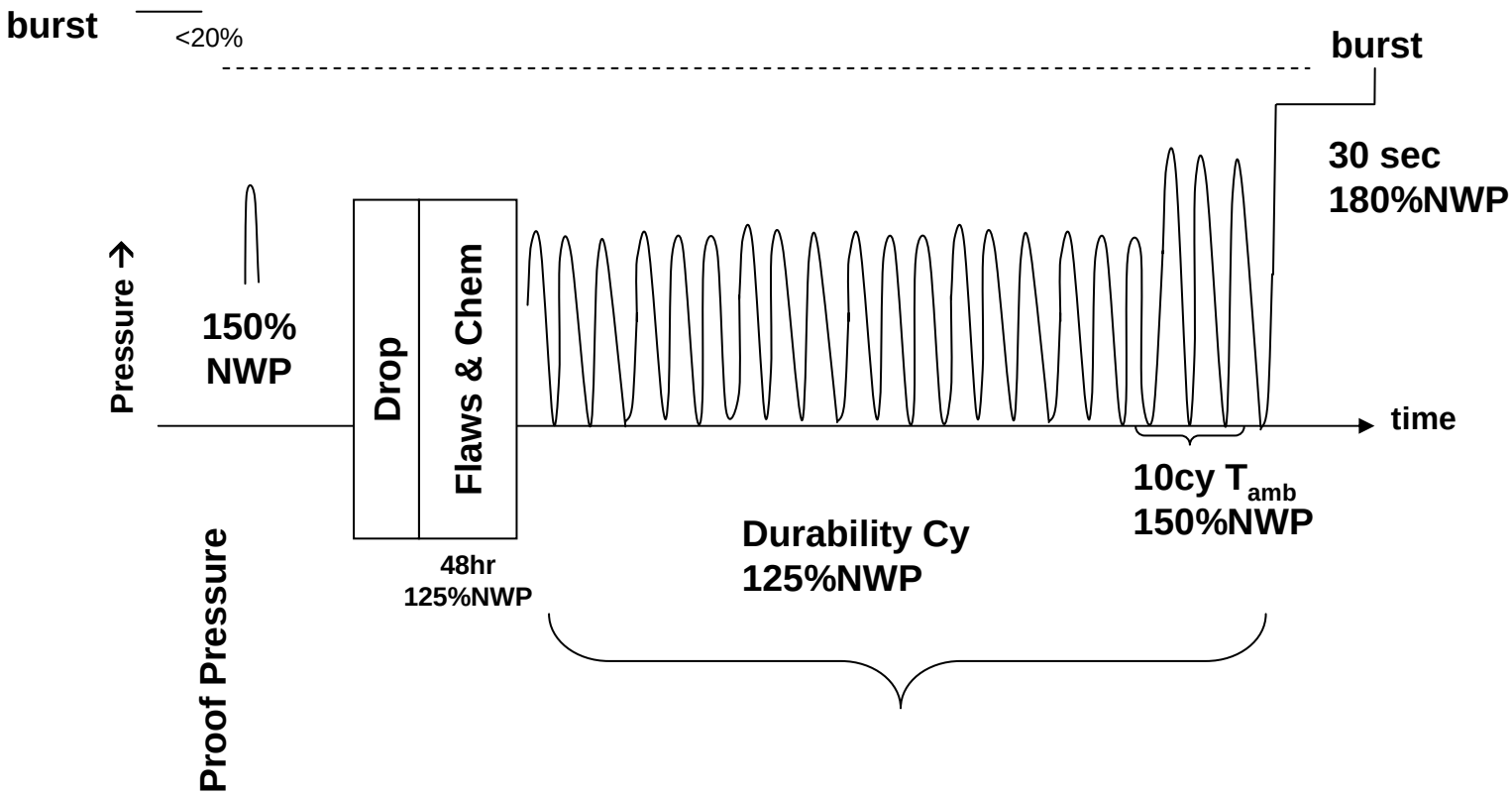
Section 5.2 – Compressed Hydrogen Storage System Performance Requirements

- Expected service performance test sequence (pneumatic pressure cycling)
- Durability performance test sequence (hydraulic pressure cycling)
- Performance under service-terminating conditions

Expected Service (pneumatic)



Durability Performance (hydraulic)



Service Terminating Conditions

Bonfire	No burst & controlled PRD release
Penetration	No burst
Burst Pressure	Manufacturer will establish new-vessel burst pressure and cycle life criteria
Cycle Life	

Key Distinctions from other Pressure Vessel Codes

- System-level performance code that is independent of storage system design.
- Uses two sequences of tests (expected service and durability performance) rather than discrete testing of virgin tanks.
- Specifies end-of-life (EOL) burst margins rather than beginning-of-life (BOL) burst margins.
- In addition to requiring EOL burst margin to be at least 1.8 times maximum working pressure, also requires EOL burst pressure to be at least 80% of virgin-tank burst pressure.
- Includes pneumatic cycling and sustained stand time (in expected service sequence).

Workplan for 2008 and 2009

- Complete validation testing, and revise SAE J2579 as appropriate based on findings.
- Develop localized fire test procedure(s) and performance criteria for possible inclusion in SAE J2579.
- Consider refinements to specific provisions based on additional data analyses:
  - Permeation requirements
  - Number of pressure cycles
  - Hold times and temperatures
- Criteria for redesign not requiring re-qualification.
- Re-qualification for additional service.
- Criteria for allowing parallel (versus series) performance testing

Summary

- JARI S 001 has almost same concept as ISO 15869.2 for Hydrogen Containers. Both of them have been derived from CNG standards.

- Revision expected to cover 70 MPa and a wider material range

- SAE J2579 provides performance based system level requirements to assess hydrogen storage safety while also facilitating future improvements in technology.

- Validation testing scheduled for completion during 2008.

Thank you !