International Partnership for Hydrogen & Fuel Cells in the Economy – Regulations Codes and Standards Working Group

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Safety Codes and Standards Program

2014 Annual Merit Review,
June 18, 2014
Project ID: SCS020

IPHE Vision

The IPHE was established in 2003 as an international intergovernmental organization to accelerate the use of hydrogen and fuel cells in the economy. It provides a mechanism for partners to organize, coordinate and implement effective, efficient and focused international research, development, demonstration and commercial utilization activities.

Australia	Germany	New Zealand
Brazil	Iceland	Norway
Canada	India	Russian Federation
China	Italy	Republic of South Africa
European Commission	Japan	United Kingdom
France	Republic of Korea	United States

Background

- Challenge and Approach:
  - Harmonized regulations, codes and standards (RCS) are essential to establishing a market-receptive environment for commercialization of Hydrogen and Fuel Cell Technologies.
  - In May 2010 (Essen, Germany), IPHE SC endorsed the importance of the RCS Working Group (WG) in taking a leading role in harmonizing RCS, from an IPHE top down perspective

Background

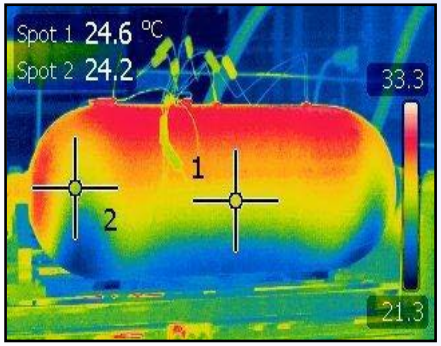
- Benefit:
  - The RCSWG's role is to create and conduct a forum where potentially contentious and controversial issues of RCS are identified and handled. The RCSWG can recommend a consensus solution and promote resolution of contentious issues.
  - The RCSWG also conducts pre-normative work to globally harmonize the execution of testing relevant to RCS.

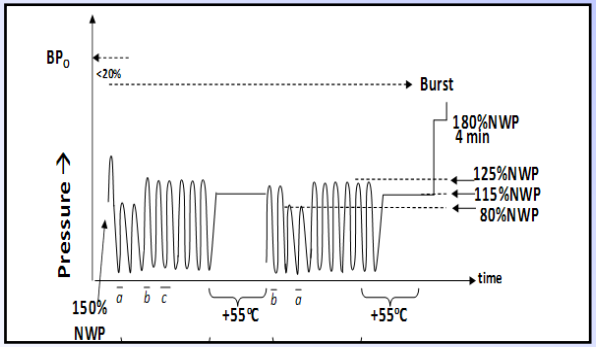
Background

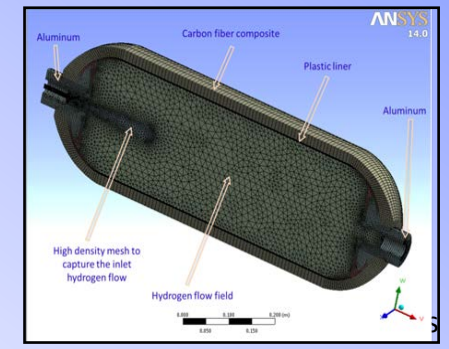
- Technical Issue:
  - There have been issues raised about the lack of uniformity in test measurement protocol related to Type IV composite overwrap pressure vessels (COPV).
- RCSWG Response:
  - A Round Robin (RR) to define a harmonized test measurement protocol.

Progress on Type IV Tank Testing Round Robin (RR)

- September 2011:
  - Launched a multi-phase Round Robin (RR) testing program for Type IV COPVs *(Japan, UK, Brazil, EC, France, Canada, China, U.S.)*
- Phase I: **Completed for hydraulic ✓**
  - Individually defined a test measurement protocol that was combined to yield a harmonized protocol that will yield consistent results independent of the test facility.

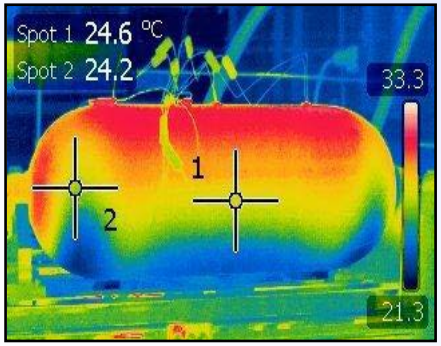


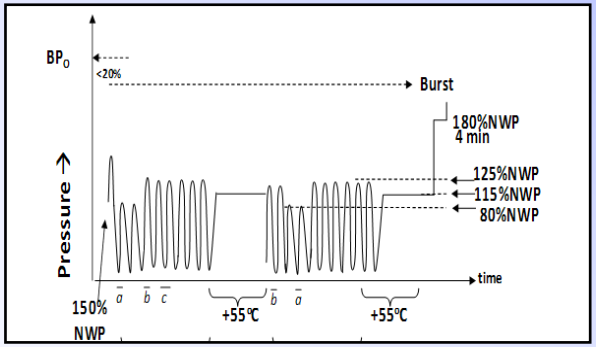


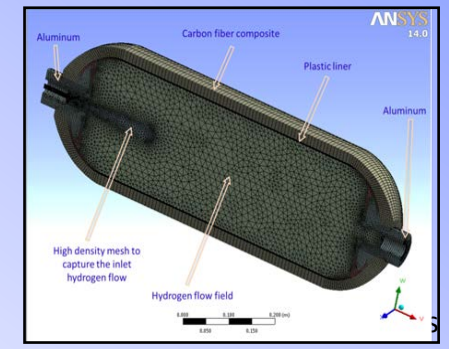


Progress on Type IV Tank Testing Round Robin (RR)

- Phase I: **Completed for hydraulic** ✓
  - Execute hydraulic and pneumatic cycle test representative of proposed requirements for composite overwrapped pressure tanks (i.e, SAE J2579, GTR, EIHP Rev 12B)
    - Four 25 MPa Type IV tanks from Hexagon Lincoln
    - Six 70 MPa Type IV tanks from CEA (expected)
    - Hydraulic testing completed
      - China & the U.S. using the 4 Hexagon Lincoln tanks
    - Pneumatic cycle tests started
      - JRC – Q4 CY2013

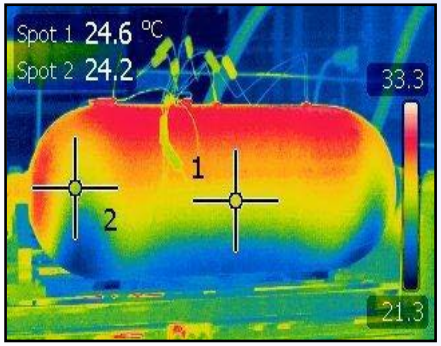


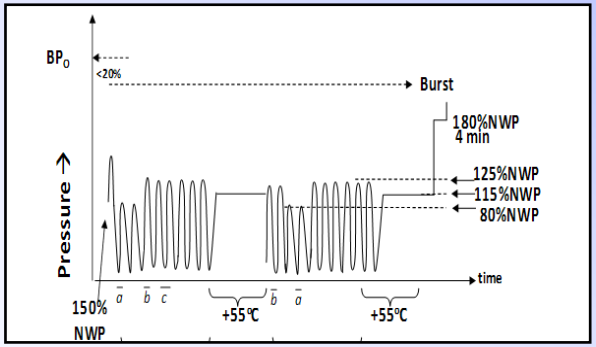


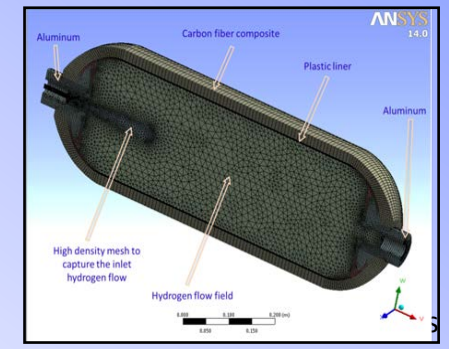


Progress on Type IV Tank Testing Round Robin (RR)

- Phase II: **Completed for hydraulic ✓**
  - Hydraulic cycle tests (up to 25 MPa)
    - U.S. testing performed at the NASA WSTF
      - Real time 24/7 access to the acquisition computer
    - China testing performed at the Institute of Process Equipment, Zhejiang University
      - Testing occurred during a site visit from U.S.
    - Lessons learned were implemented in a revised test method protocol for the 2nd tank







Progress on Type IV Tank Testing Round Robin (RR)

IPHE RCSWG Meeting

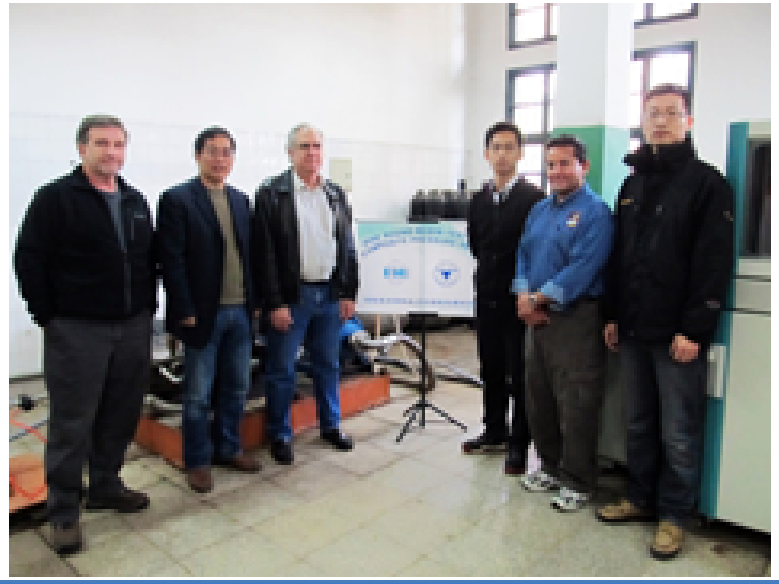
September 12, 2013 *Brussels - Belgium*

1. Objective

◆ The purpose of IPHE round robin is to establish a harmonized test measurement method protocol that when applied around the world, consistency in the test measurements can be assured.

◆ After the discussion in IPHE RCSWG, a round robin ambient pressure cycle tests for type IV tanks were conducted in the U.S. and China.

◆ This report will introduce the test in China.



Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

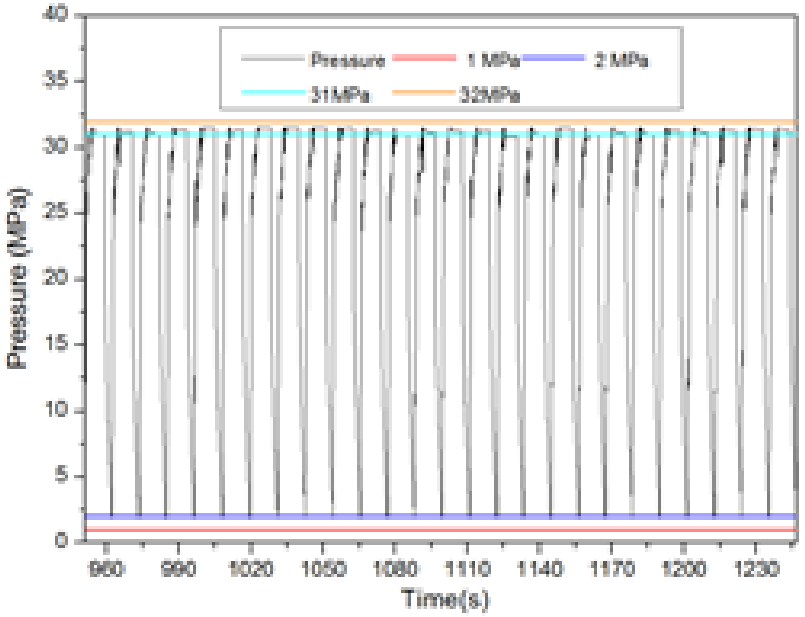
IPHE RCSWG Meeting

September 12, 2013 *Brussels - Belgium*

4. Test Results

- After 15,000 cycles, there are no failure for the both test tanks. The water pressure and the temperature variations are shown below.

4.1 Pressure variation



- Pressure range
  Low: 1 ≤P≤ 2 MPa
  High: 31.04MPa≤P≤32.04 MPa
- Dwell time = 0 s at the minimum pressure
- Dwell time = 4 s at the maximum pressure
- Cycle frequency is about 5.6 / min

Zhejiang University, Hangzhou, P. R. China

Progress on Type IV Tank Testing Round Robin (RR)

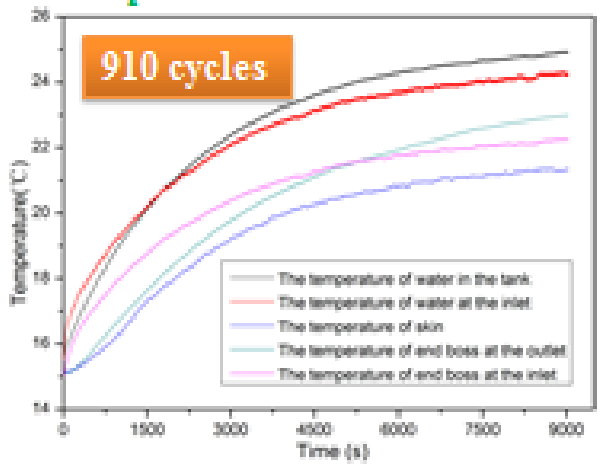
Accomplishment

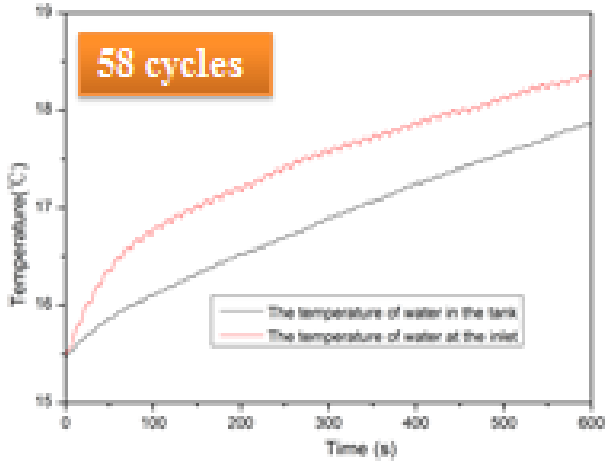
IPHE RCSWG Meeting

September 12, 2013 *Brussels – Belgium*

4. Test Results

4.2 Temperature variation





- Ambient temperature: 15℃
- During the idle period, the pressure was maintained at 1~2MPa.
- After about 910 pressure cycles, the temperature of water in the tank rise to 25℃.
- Only 800 ~ 1000 pressure cycles are conducted per day to control the temperature rise and ensure the similar initial temperature.

Zhejiang University, Hangzhou, P. R. China

Progress on Type IV Tank Testing Round Robin (RR)

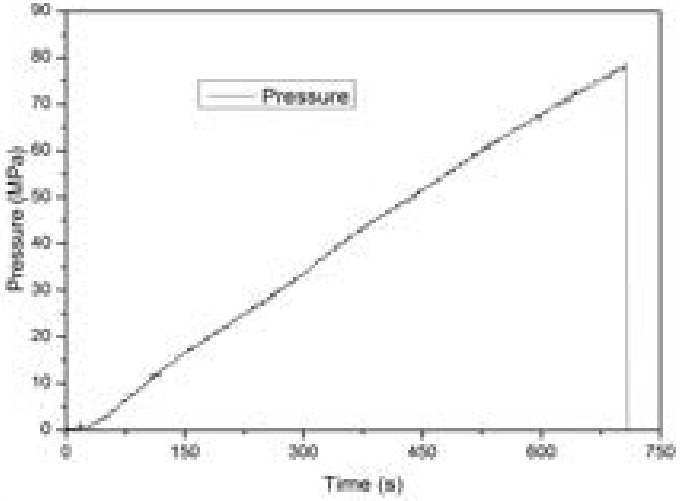
Accomplishment

IPHE RCSWG Meeting

September 12, 2013 *Brussels - Belgium*

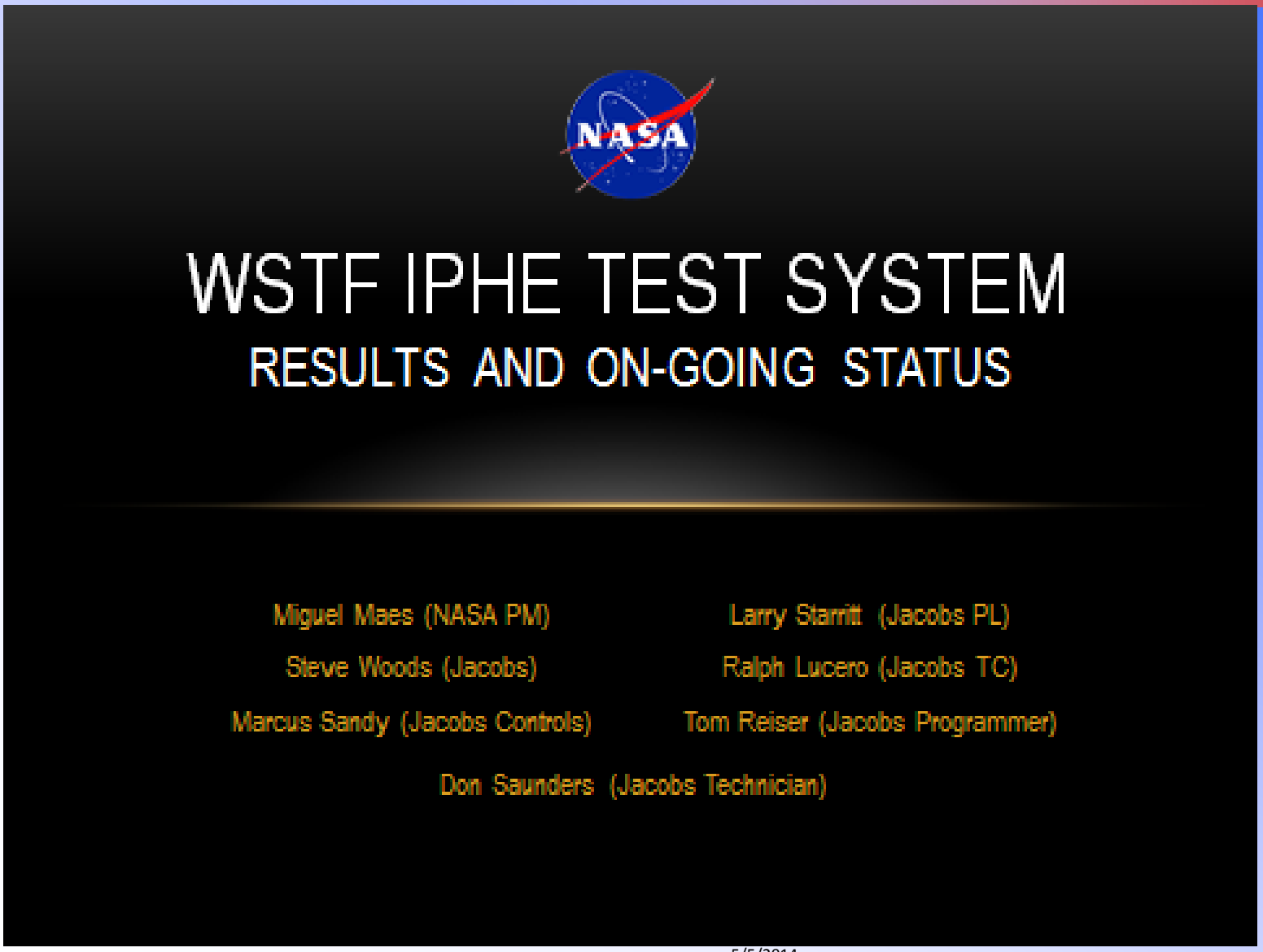
4. Test Results

4.3 Residual Strength Burst Test (tank #2)



- The burst pressure of tank #2: 78.7 MPa.

Progress on Type IV Tank Testing Round Robin (RR)



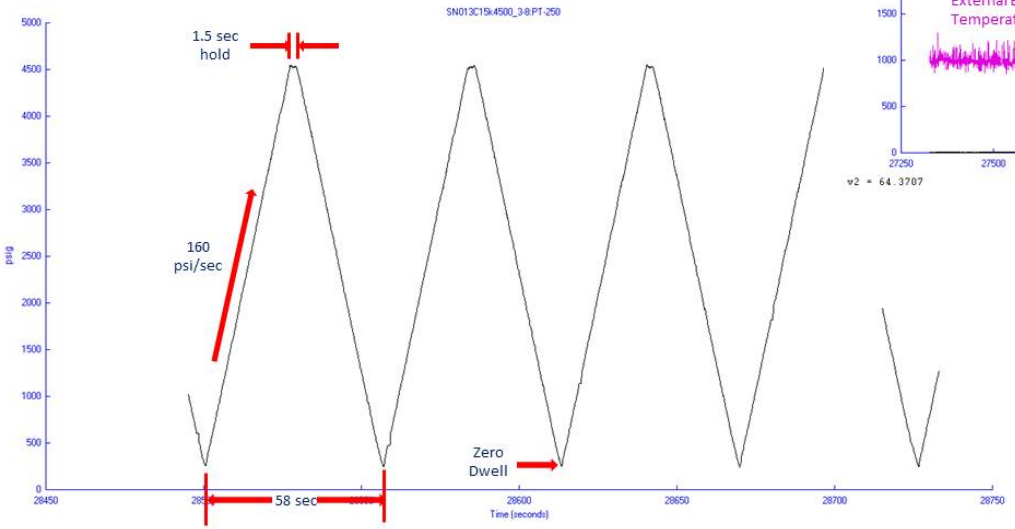
Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

Pass thru configuration with inline chiller. Temperatures reach steady state in about 30 minutes.

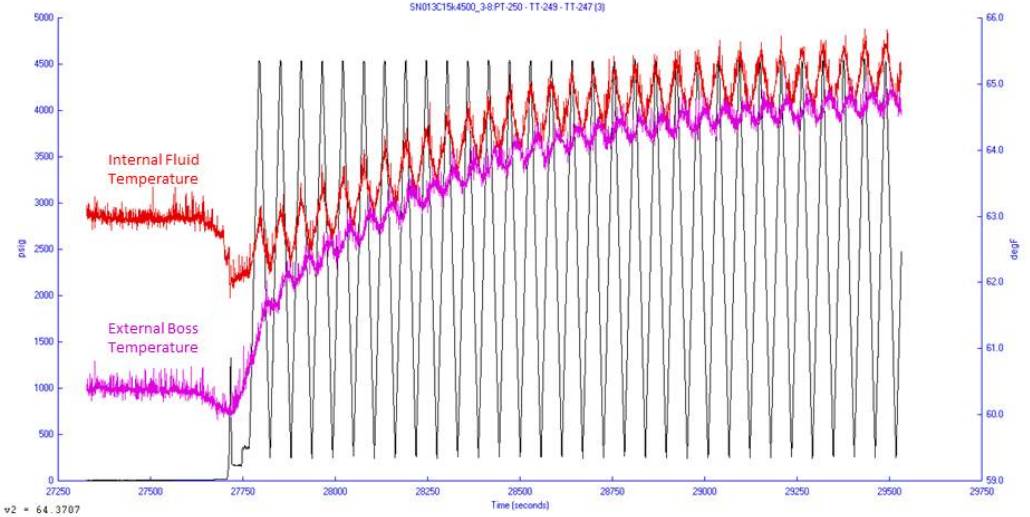
Typical Pressure Profile

(1 cycle per min)



Cycle effect on Temperature

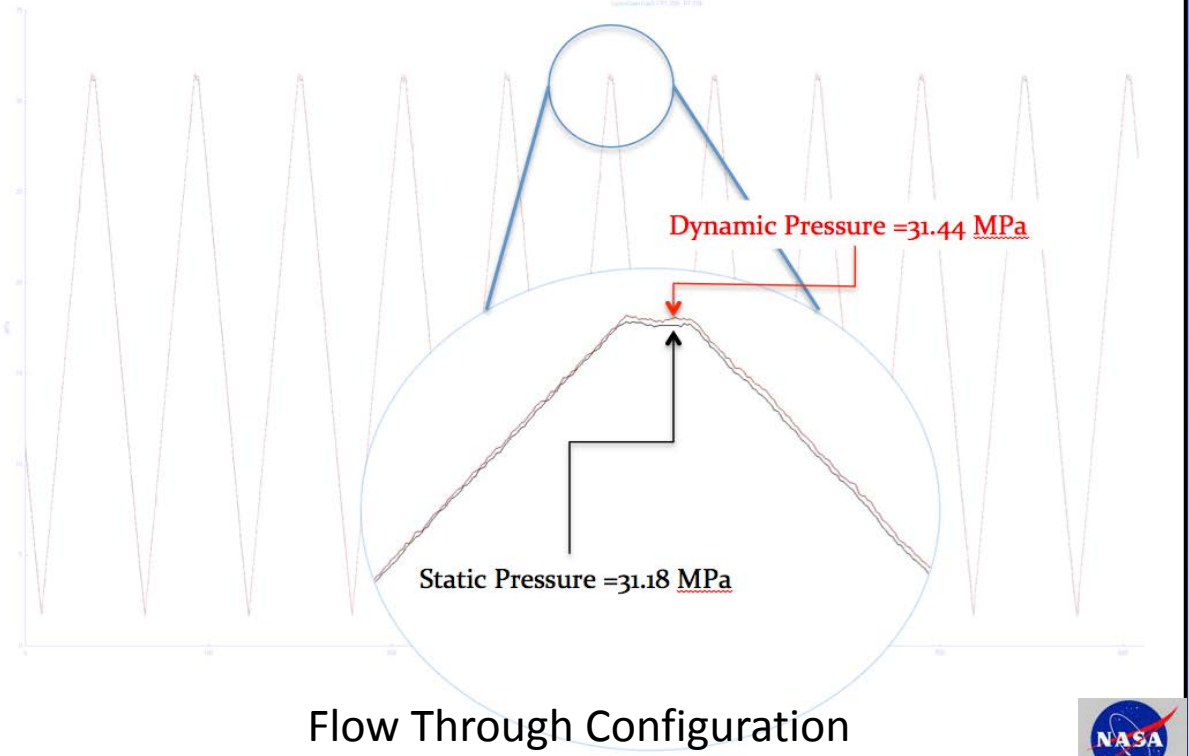
(1 cycle per min)



The boss temperature is lower than the in-tank temperature by about 0.28 °C

Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

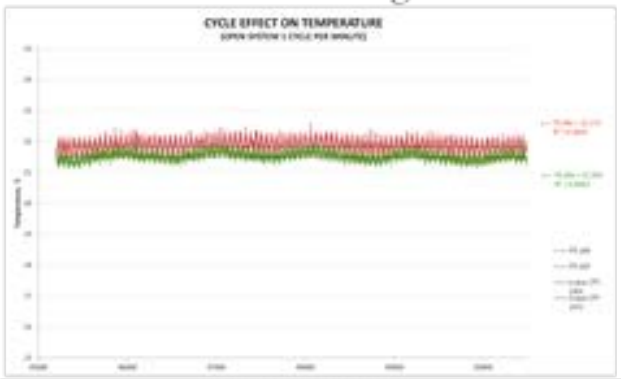
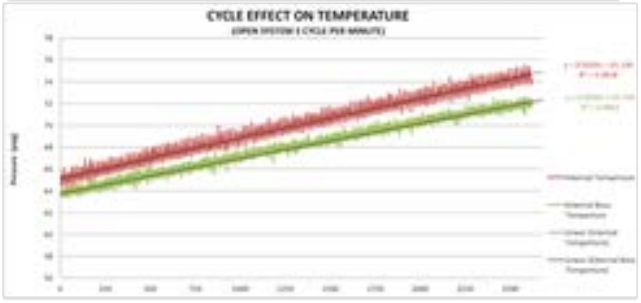
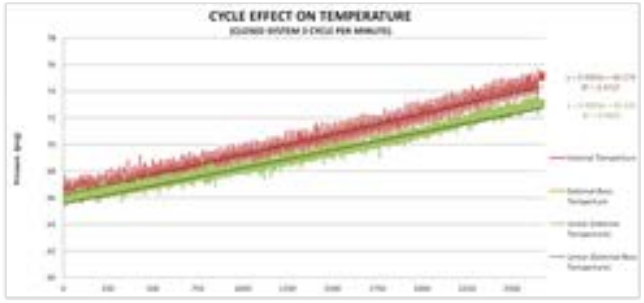


Flow Through Configuration

- ΔP between dynamic and static is 0.26 MPa (2.6 Bar)
  - Arguably a very small number ~1% FS for this work.
- ΔP for the dead-ended configuration was effectively 0.0

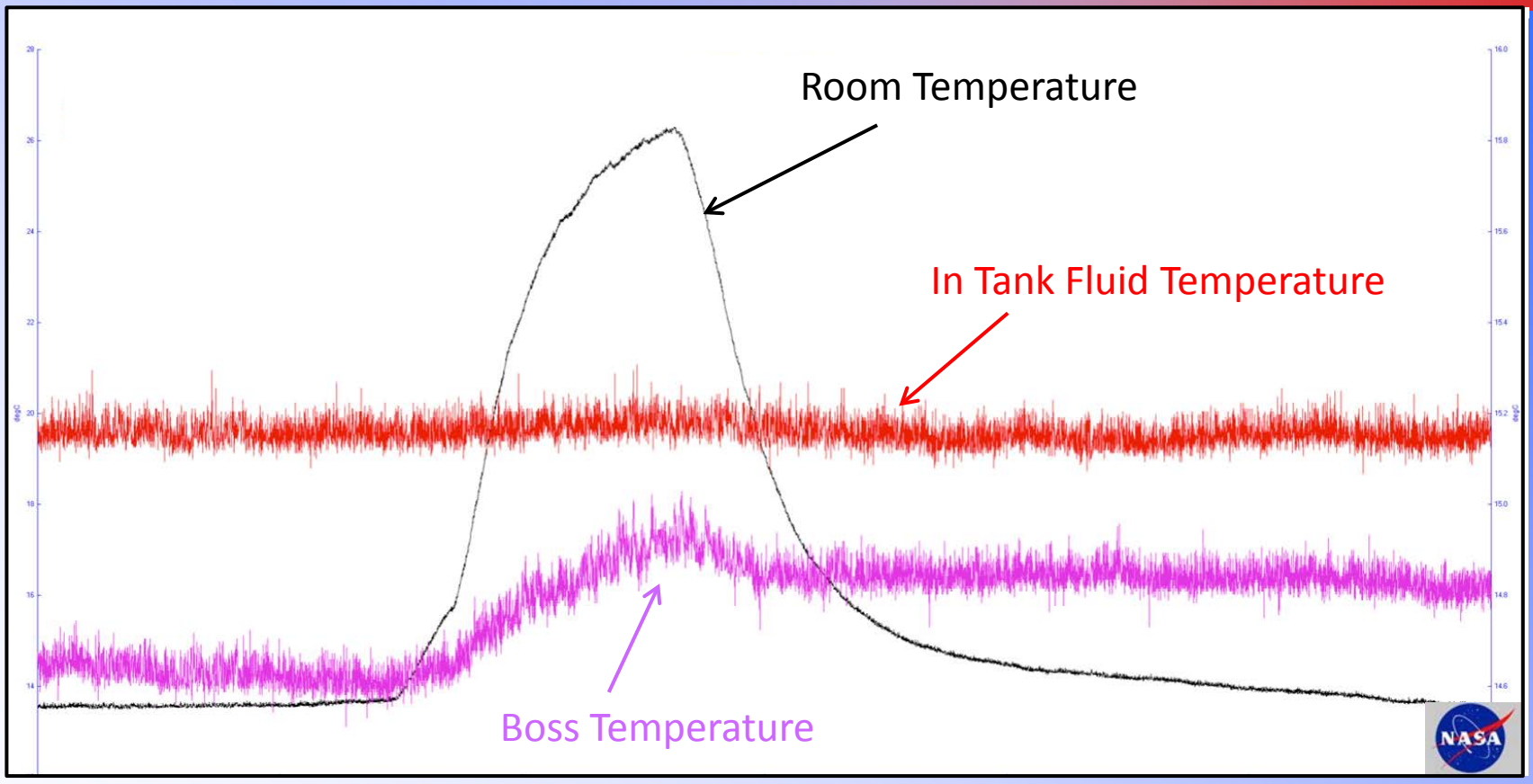
Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

	Flow-Through	Dead-ended
1 cycle/min		
3 cycle/min		

$T_{boss} < T_{tank}$ & it gets worse with increasing number of cycles.

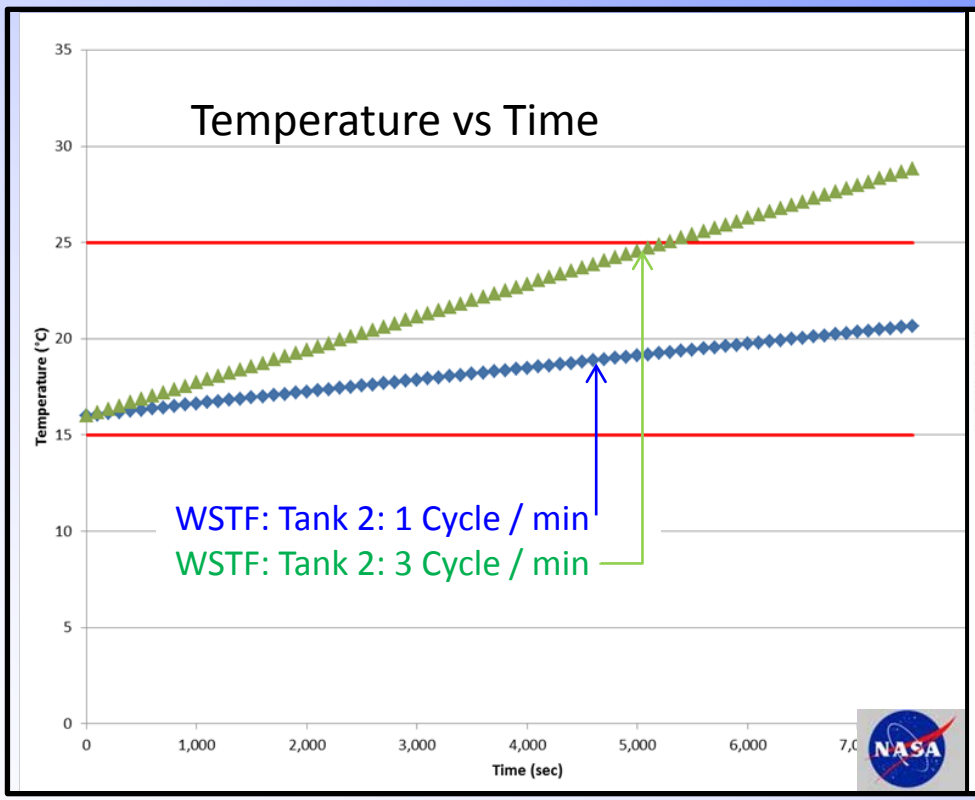
Progress on Type IV Tank Testing
Round Robin (RR) Accomplishment

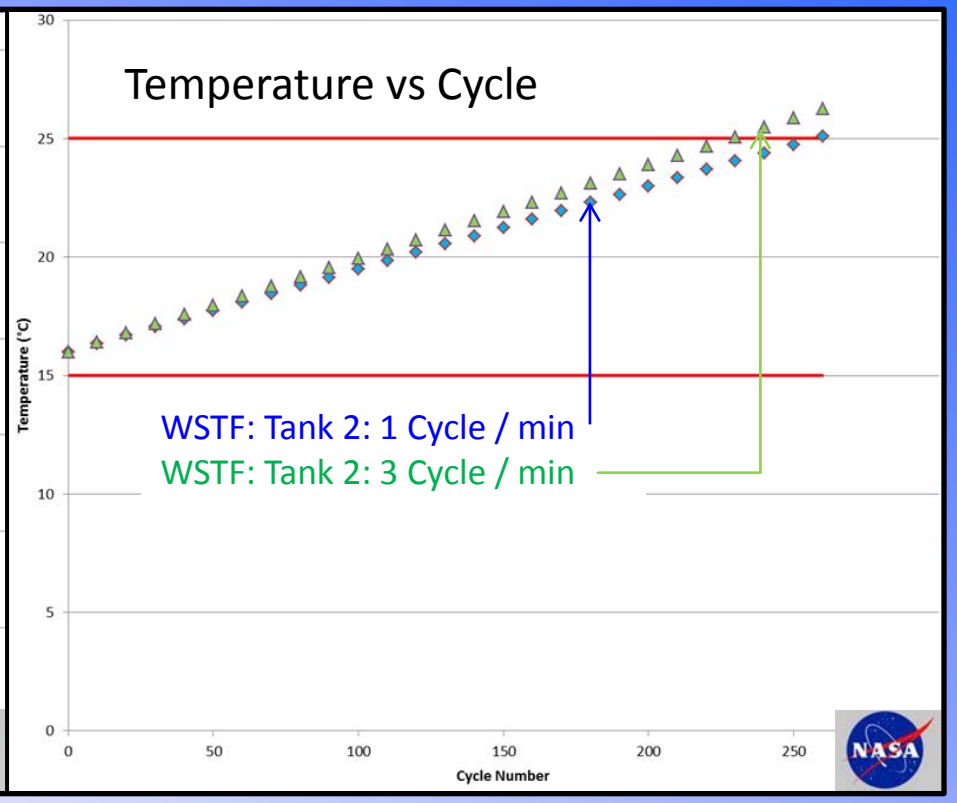


- Boss Temperature is affected by the ambient temperature
  - Care needs to be taken to isolate the boss measurement
    - this was corrected on tank 2 at both facilities

Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

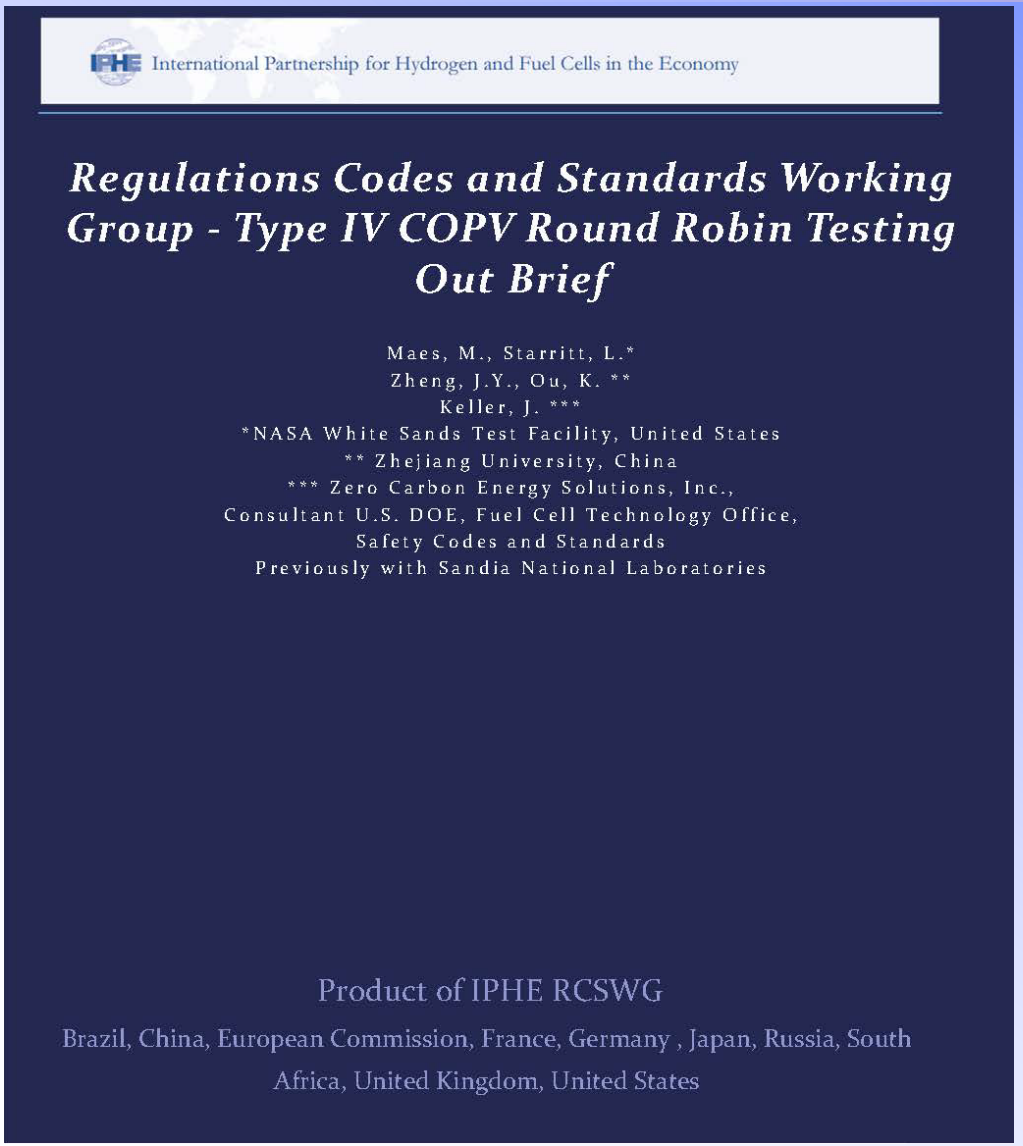




- Temperature increase is system dependent
  - Temperature increase on a per cycle basis is roughly independent of cycle rate (every thing else being constant)
  - Upper temperature limit reached after about ~250 cycles

Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment



International Partnership for Hydrogen and Fuel Cells in the Economy

Regulations Codes and Standards Working Group - Type IV COPV Round Robin Testing Out Brief

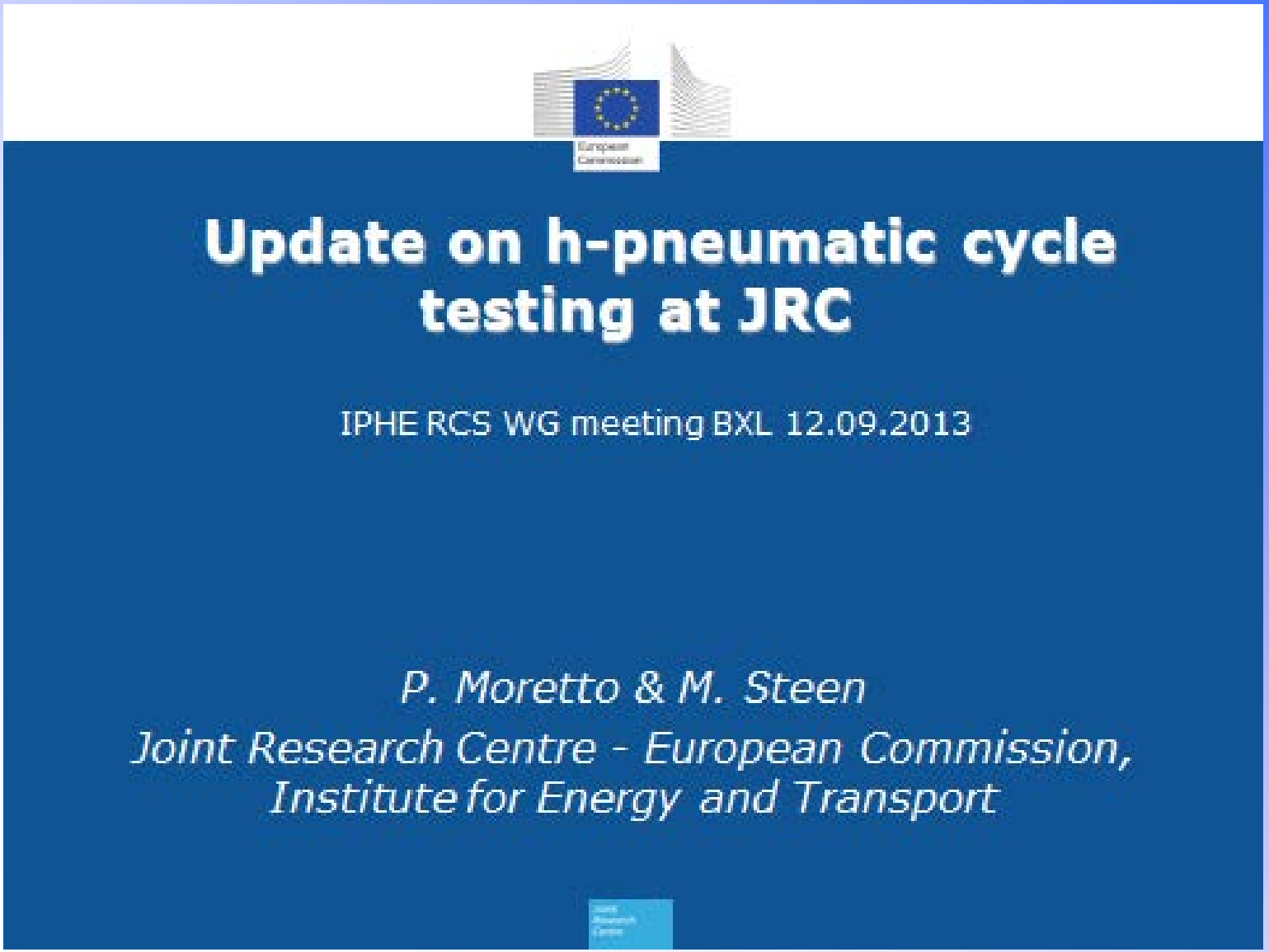
Maes, M., Starritt, L.*
Zheng, J.Y., Ou, K. **
Keller, J. ***
*NASA White Sands Test Facility, United States
** Zhejiang University, China
*** Zero Carbon Energy Solutions, Inc.,
Consultant U.S. DOE, Fuel Cell Technology Office,
Safety Codes and Standards
Previously with Sandia National Laboratories

Product of IPHE RCSWG

Brazil, China, European Commission, France, Germany , Japan, Russia, South Africa, United Kingdom, United States

- Final Report Submitted to the IPHE SC at the May 20-21 Spring Meeting.

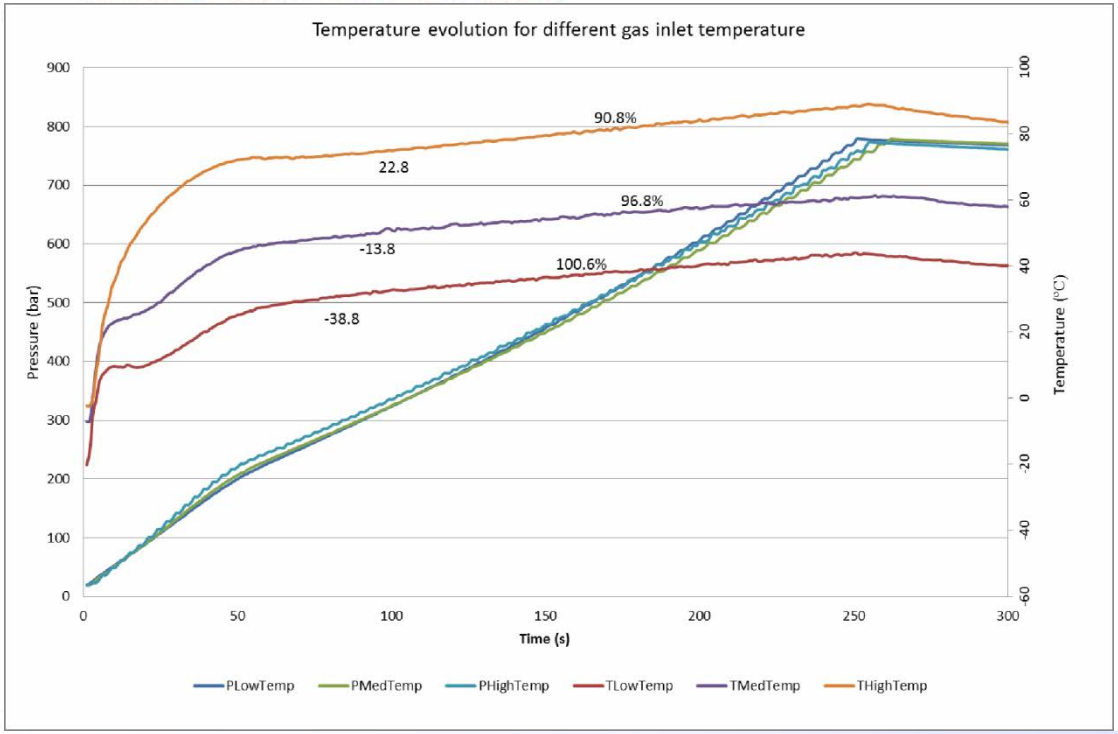
Progress on Type IV Tank Testing Round Robin (RR)



Progress on Type IV Tank Testing Round Robin (RR)

Recent GasTeF results

Filling with pre-cooling

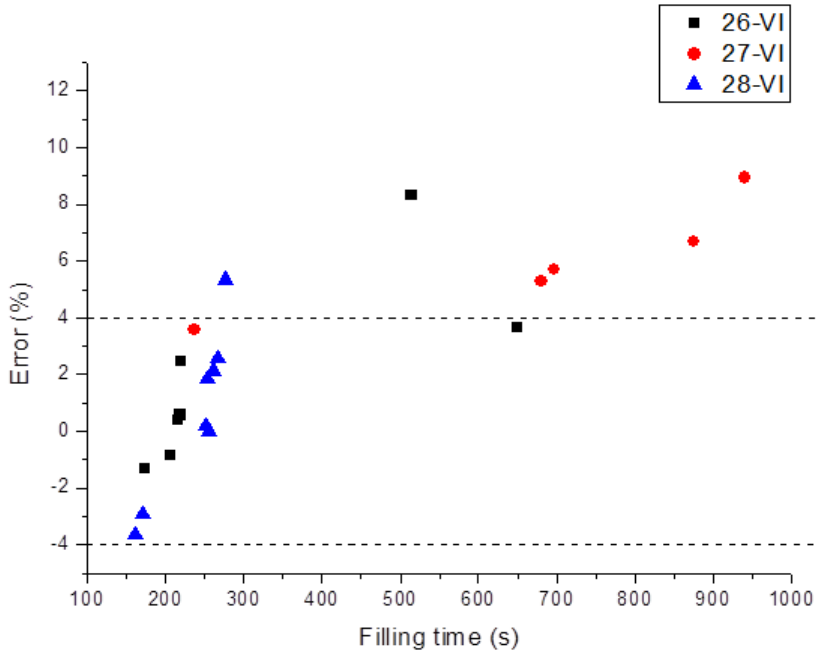


- Pneumatic Testing @ 70 MPa
  - Phase II (Cycle Execution)
    - Initial results from JRC testing completed

Fueling Station Metrology (Metering)

Recent GasTeF upgrade

The relative error is directly related to the mass flow: this flow meter works well for short filling time (high mass flow rates)



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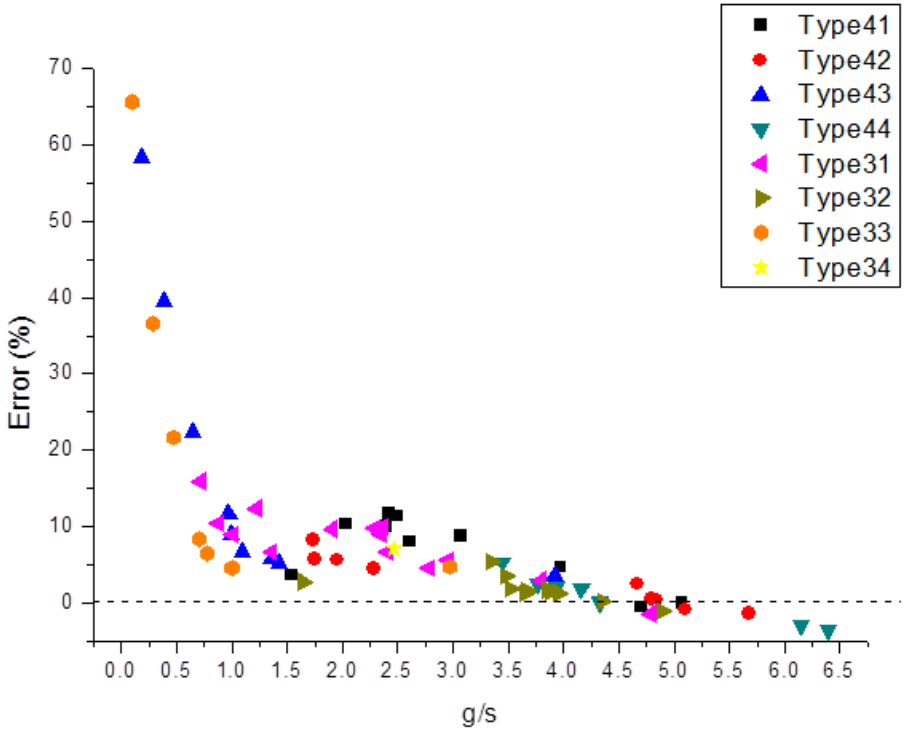
Fueling Station Metrology (Metering)

Recent GasTeF upgrade

By extending the experiments at very slow average mass flow rates (ca. 1.0 g/s), errors jumps to unacceptable relative error values. Work is in progress to test other instruments.



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New Activities

- Launched a new RR on Fuel Quality Effects on Stack Performance
  - 5 member countries have been identified (all are invited) to comprise a task force to define this new RR
    - Endorsement from the SC received

This activity is on Hold

Proposals Seeking RCSWG Concurrence and SC Approval

- Component reliability database
  - Event frequency data
    - For example; mean time between failures, type of release, the number of uneventful events (denominator in the frequency data)…
- Component Material Compatibility Learning RR
  - ANSI/CSA CHMC 1 - 2014 Test Method for Evaluating Material Compatibility in Compressed Hydrogen Applications – Phase I – Metals

Member Countries

Country	Point of Contact	Alternate
Brazil	**Sergio Oliveira**	**Newton Pimenta**
China	**Jinyang Zheng**	
European Commission	**Marc Steen**	**Pietro Moretto**
France	**Pierre Serre-Combe**	**Laurent Antonii**
Germany	**Thorsten Herbert**	
Italy	Romano Borchielline	Massimo Santarelli
Japan	**Kazuo Koseki**	**Akiteru Maruta**
New Zealand	Alister Gardiner	
Norway	Gerd Petra Haugom	
Russian Federation	Sergey V.Korobtsev	
South Africa	**Brian North**	
United Kingdom	Stuart Hawksworth	
United States	**Sunita Satyapal**	**Jay Keller**

- **Note**
  - **Countries noted in dark blue are the most active**
  - **No contacts yet from Australia, Iceland and South Korea**
  - **Canada and India have been dropped from our list due to inactivity**

Thank you.