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

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Safety Codes and Standards Program

2013 Annual Merit Review,
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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

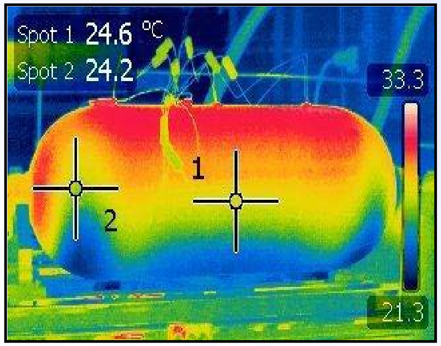
- Benefit:
  - The RCSWG's role is to create and conduct a forum where potentially contentious and controversial issues of RCS are identified and handled. The RCSWG can recommend a consensus solution and promote resolution of contentious issues.
  - The RCSWG also conducts pre-normative work to globally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

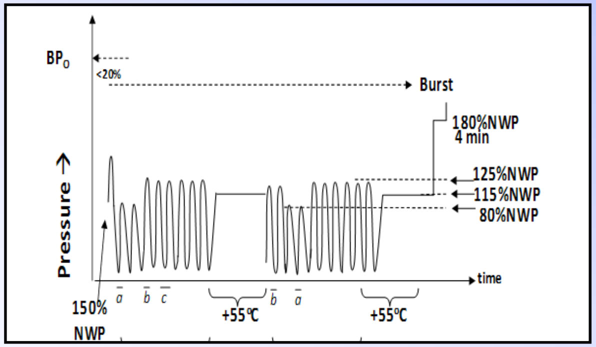
Background

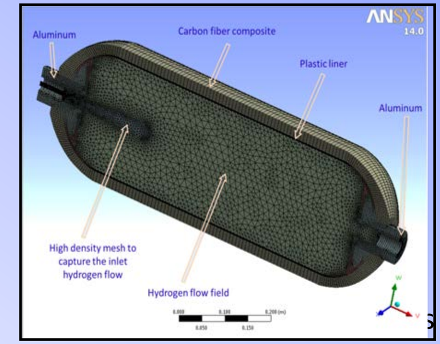
- Technical Issue:
  - There have been issues raised about the lack of uniformity in test measurement protocol related to Type IV composite overwrap pressure vessels (COPV).
- RCSWG Response:
  - A Round Robin (RR) to define a harmonized test measurement protocol.

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.

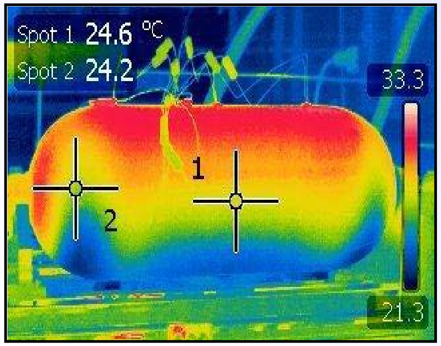


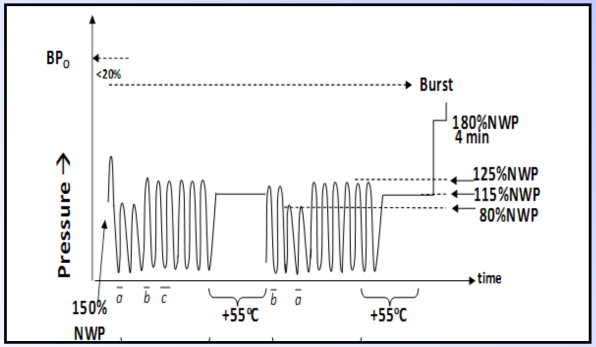


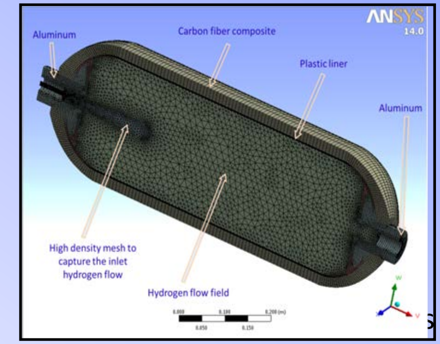


Progress on Type IV Tank Testing Round Robin (RR)

- Phase II:
  - Execute hydraulic and pneumatic cycle test representative of proposed requirements for composite overwrapped pressure tanks (i.e, SAE J2579, GTR, EIHP Rev 12B)
    - Four 35 MPa Type IV tanks from Hexagon Lincoln
    - Six 70 MPa Type IV tanks from CEA
    - Hydraulic testing completed on the first of two tanks
      - China & the U.S. used 2 of 4 Hexagon Lincoln tanks
    - Pneumatic cycle tests to start
      - JRC and SNL – Q4 CY2013

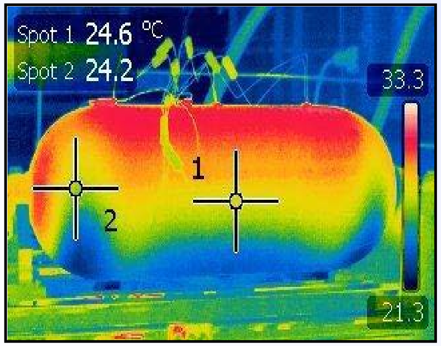


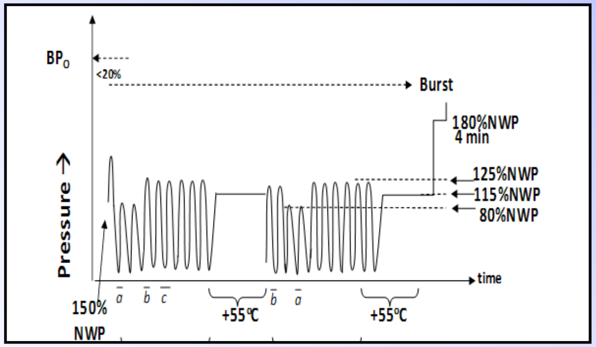


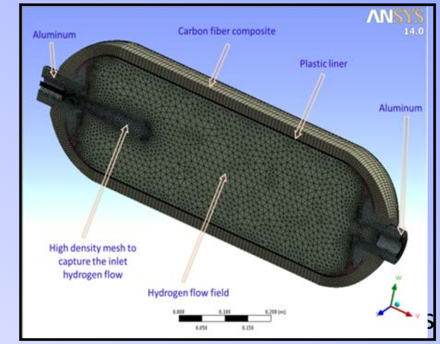


Progress on Type IV Tank Testing Round Robin (RR)

- Phase II: Hydraulic cycle tests (up to 35 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)

Accomplishment

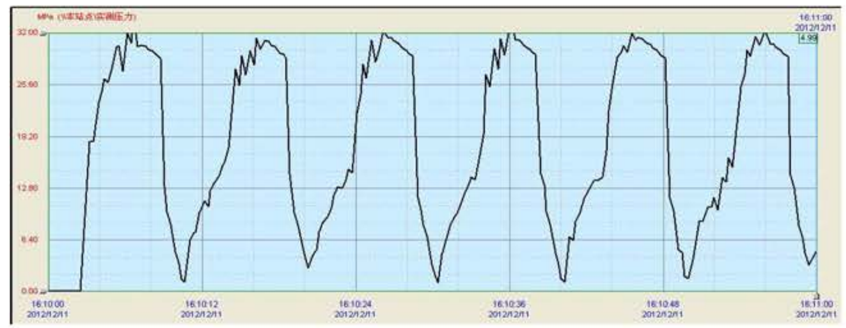
IPHE Round Robin Test for Composite Pressure Vessel

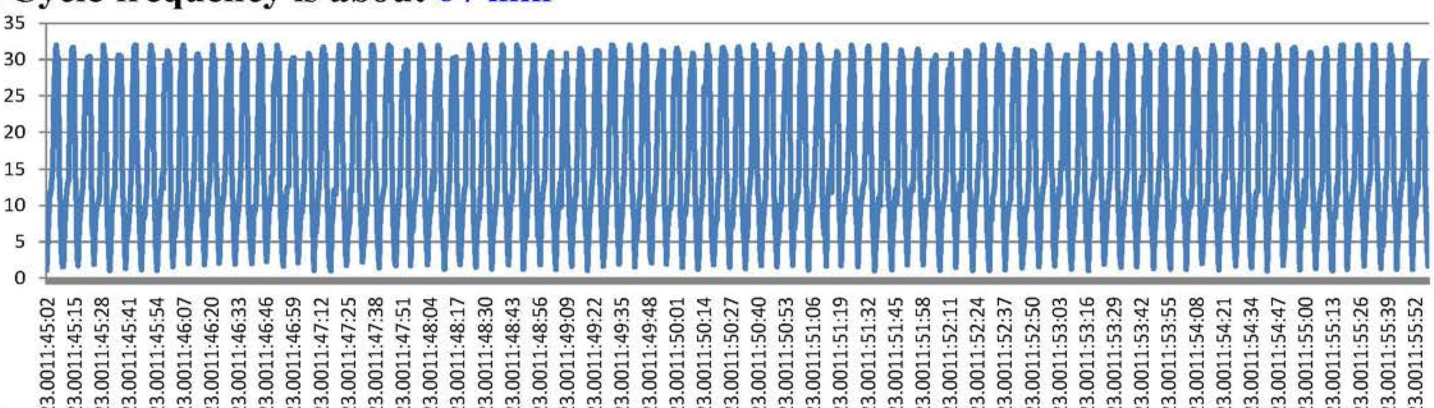
Pressure Control

- **Pressure range**

  Low: 1 ≤ P ≤ 2 MPa
  High: 31.04 MPa ≤ P ≤ 32.04 MPa

- **Dwell time = 0 s at the minimum pressure**
- **Dwell time = 2 s at the maximum pressure**
- **Cycle frequency is about 6 / min**





Institute of Process Equipment, Zhejiang University, China

Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

IPHE Round Robin Test for Composite Pressure Vessel

Temperature Control

Pressure cycle is stopped in every 100 cycles to control the temperature. During the test:

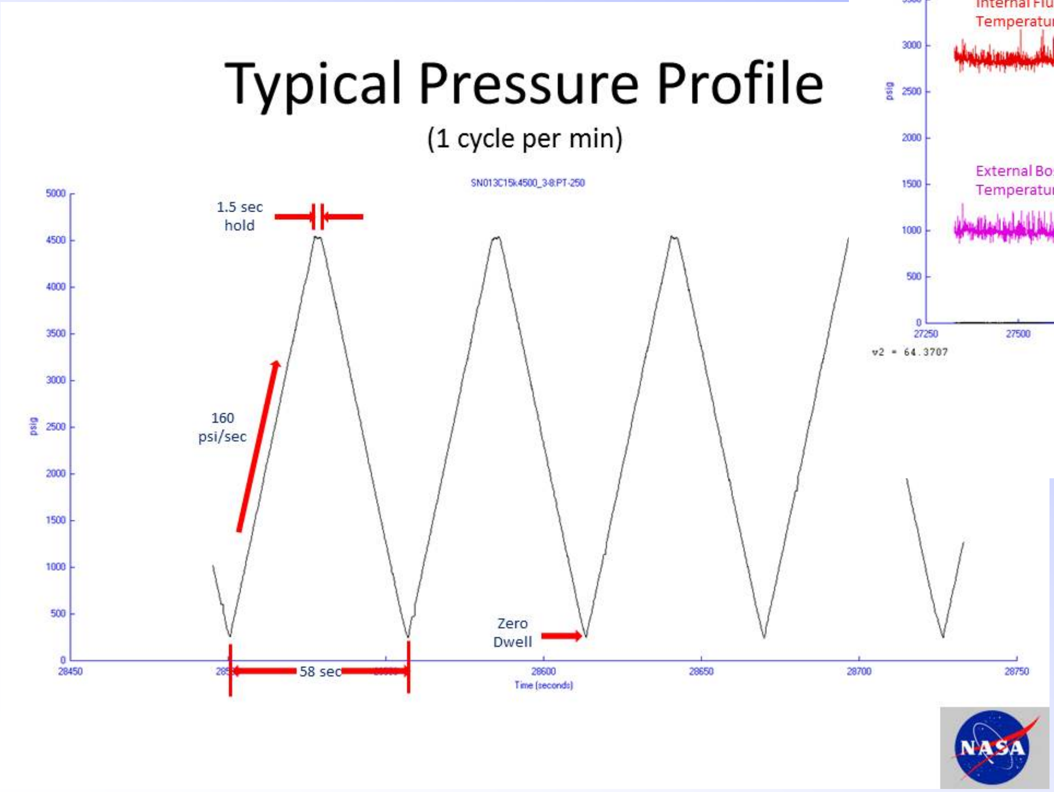
- **The temperature of the ambient air is controlled at 15-25℃.**
- **The temperature of the front end boss is controlled at 15-25℃.**
- **The temperature of the back end boss is controlled at 15-25℃.**
- **The temperature of the skin is controlled at 15-25℃.**

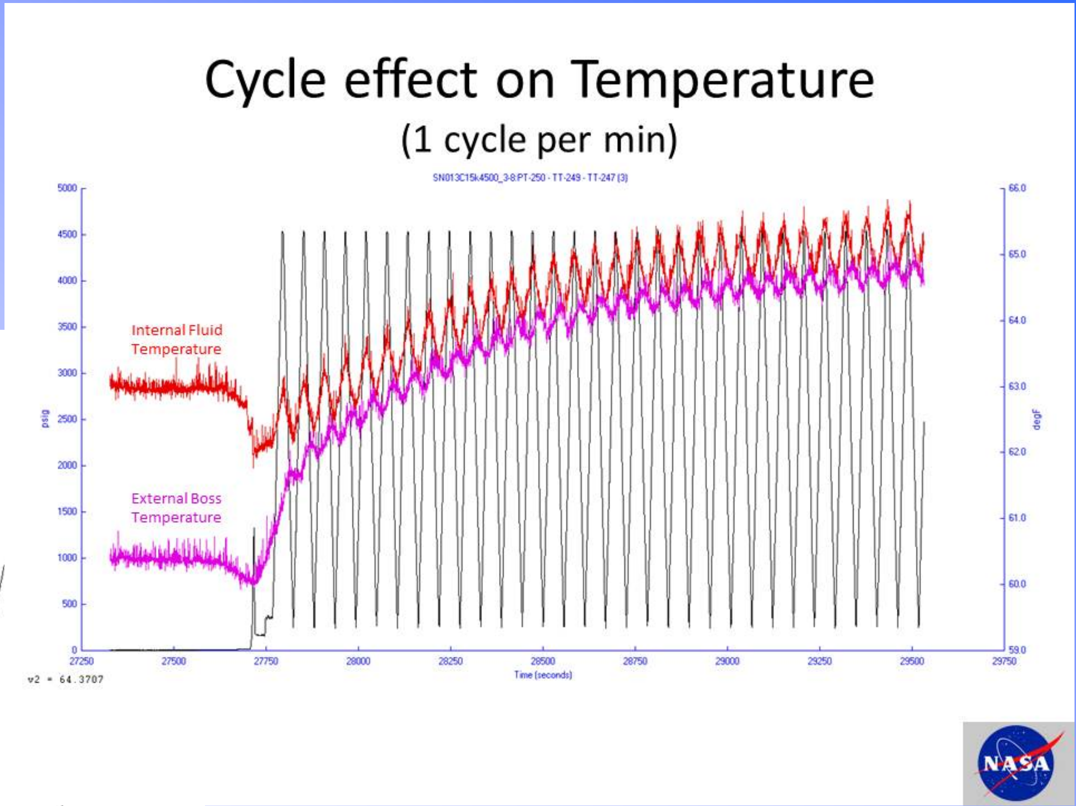
Institute of Process Equipment, Zhejiang University, China

Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

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





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

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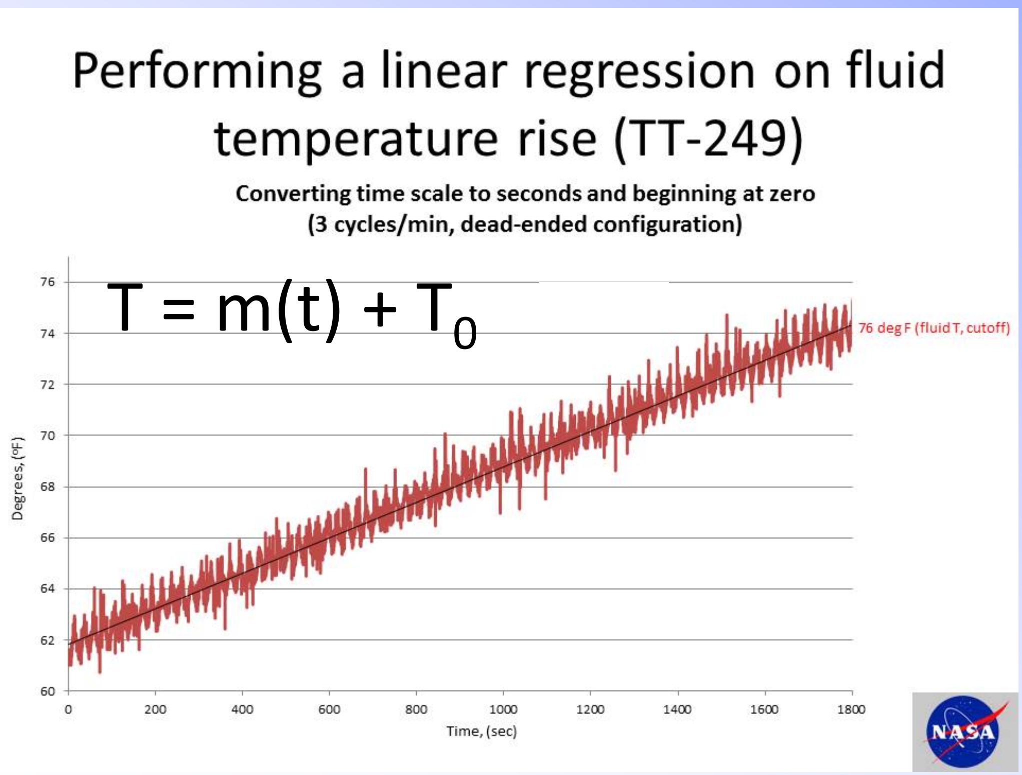
Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

3 Cycle / Minute:
Dead ended, no chiller



- In-tank T_{tank}
  - $m = 0.00389$ °C / sec
  - $T_0 = 16.57$ °C
- On the boss T_{boss}
  - $m = 0.00367$ °C / sec
  - $T_0 = 16.13$ °C
- After 100 cycles
  - $T_{tank} = 24.35$ °C
  - $T_{boss} = 23.46$ °C

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

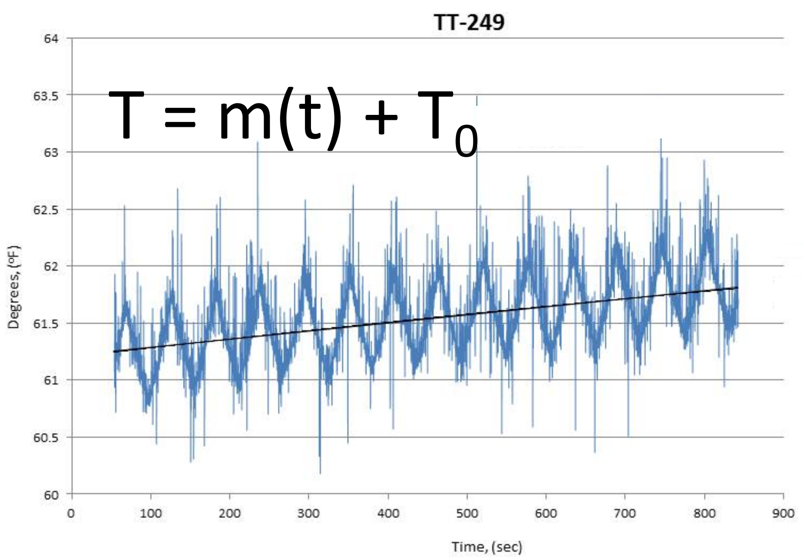
Progress on Type IV Tank Testing Round Robin (RR)

Accomplishment

1, 3, 6 cycle / min; dead ended

Note: the 6 cycle / min case was extrapolated from the 1 and 3 cycle / min cases, the data at 1 cycle / min was a 15 cycle sample

Performing a linear regression on tank fluid temperature rise (TT-249)



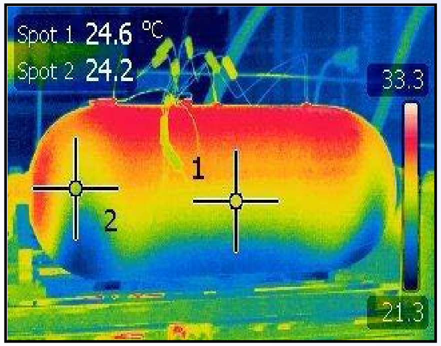
- T_{tank} @ 1 cycle / min
  - m = 0.00039 ºC / sec
  - T_0 = 16.23 ºC
- T_{tank} @ 3 cycle / min
  - m = 0.00389 ºC / sec
  - T_0 = 16.57 ºC
- T_{tank} @ 6 cycle / min
  - m ~ 0.00914 ºC / sec
  - T_0 ~ 16.40 ºC

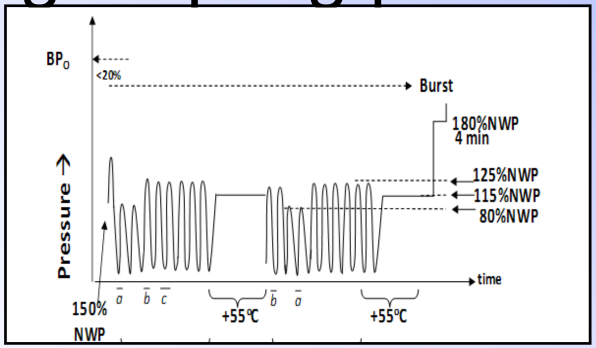
$15 \leq T_{tank} \leq 25$ C ($59 \leq T_{tank} \leq 77$ F)

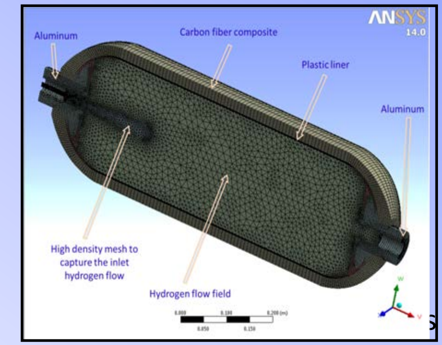
- After 100 cycles
  - T_1 = 18.57 ºC (T_{1p}~18.79 ºC)
  - T_3 = 24.35 ºC (T_{3p}~24.58 ºC)
  - T_6 ~ 25.54 ºC (T_{6p}~25.77 ºC)

Progress on Type IV Tank Testing Round Robin (RR)

- Pneumatic Testing @ 70 MPa
  - To be performed by JRC/EC and SNL/US
    - Gaps have been identified for executing pneumatic testing in both facilities
      - JRC facilities have been upgraded
      - SNL facilities are being upgraded
        - (to be completed Q4 CY2013)
  - Both facilities have developed a detailed 3-D CFD and thermal transport numerical model of the in-tank filling/empting process

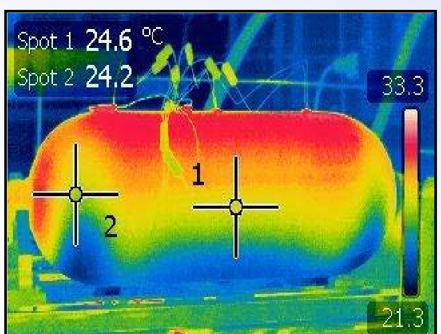


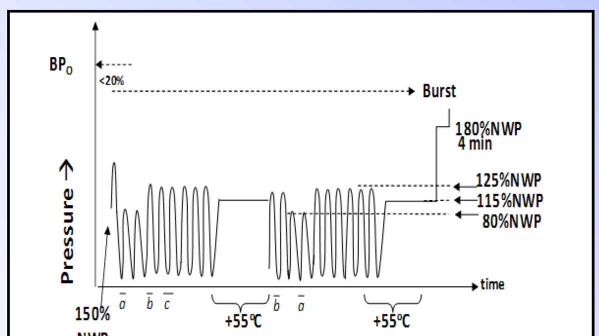


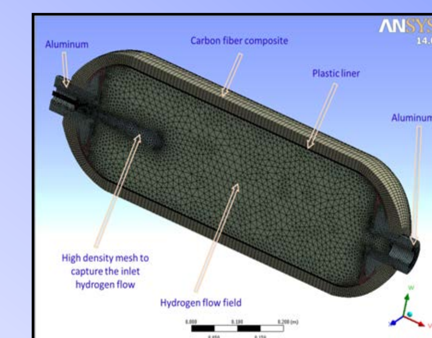


Progress on Type IV Tank Testing Round Robin (RR)

- Pneumatic Testing @ 70 MPa
  - Type IV COPV tanks supplied by CEA
    - Scheduled for delivery Q1 CY2013
      - Note: 2 of the 6 CEA 70 MPa tanks are slated for hydraulic testing
  - Phase I (Cycle test definition)
    - Modified/adapted from the hydraulic cycle test protocol
    - Completed Q1 CY2013

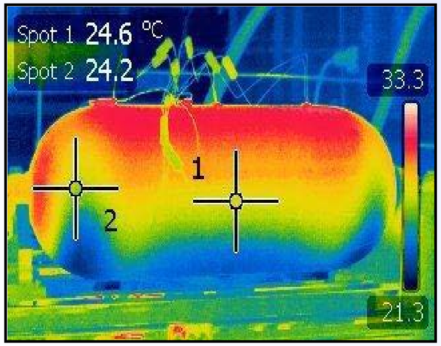


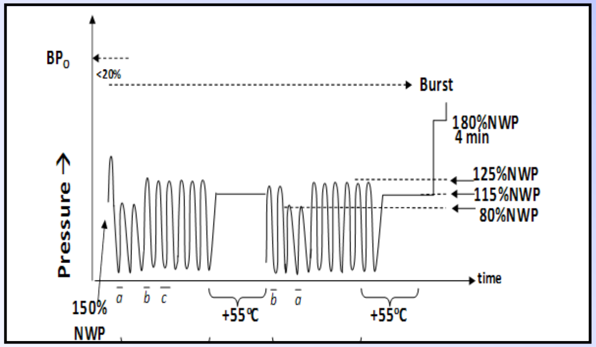


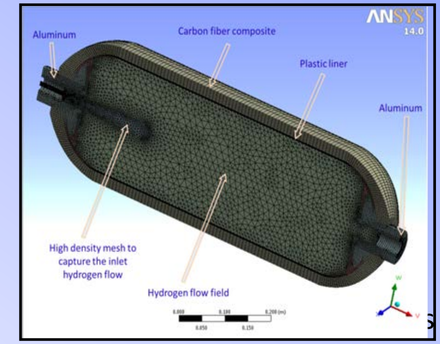


Progress on Type IV Tank Testing Round Robin (RR)

- Pneumatic Testing @ 70 MPa
  - Phase II (Cycle Execution)
    - Test will commence on one tank @ JRC, then with refinement of the protocol will proceed to SNL and continue @ JRC
    - Second round of CEA tanks may be instrumented with thermocouples at the time of manufacture







New Activities Proposed

- Launch 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

New Activities Proposed

- Fueling Station Metrology (Metering)
  - Exploit the outcomes of the pneumatic part of the tank testing RR
    - As a direct result of the pneumatic RR there will be two laboratories (JRC and SNL) that can perform mass flow rate measurements compliant with metrology requirements (OIML R139 - EU and NIST Handbook 44 - US)
  - This provides an opportunity for leveraging tank RR efforts: pre-normative issues related to metering
    - The decision on this proposed work will be taken after completion of the Tank RR

RCSWG RR Time Line - Hydraulic

Determined the protocol and prepare to describe how to execute and validate the measurement protocol.

Meeting Sept 13; *San Francisco, CA*

Meeting Oct 6th; Teleconference

Execute Phase II Round Robin Test Matrix

Oct 2011 – March 2012 | March – May 2012 | May – Sept 2012 | Sept – Oct 2012 | Nov 2012 | Jan 2013

Meeting March 7-8; Hangzhou, China

Meeting May 14th. Report Test Protocol

RCSWG Final Report

Refine test protocol and continue with testing if needed

Define test method protocol

RCSWG RR Time Line - Pneumatic

Meeting Sept 13;
San Francisco, CA

Meeting Oct 6th;
Teleconference

Determined the protocol and prepare to describe how to execute and validate the measurement protocol.

Oct 2011 – March 2012

Meeting March 7-8;
Hangzhou, China

Execute individual test method protocol, verify results (JRC & SNL)

March – May 2012

Meeting May 14th.
Report Test Protocol and develop harmonized test method protocol

May – Sept 2012

Phase I RR Draft test cycle sequence defined

Tank 1 Delivery from CEA to JRC

Sept – Dec 2012

Jan 2013

Refine test protocol

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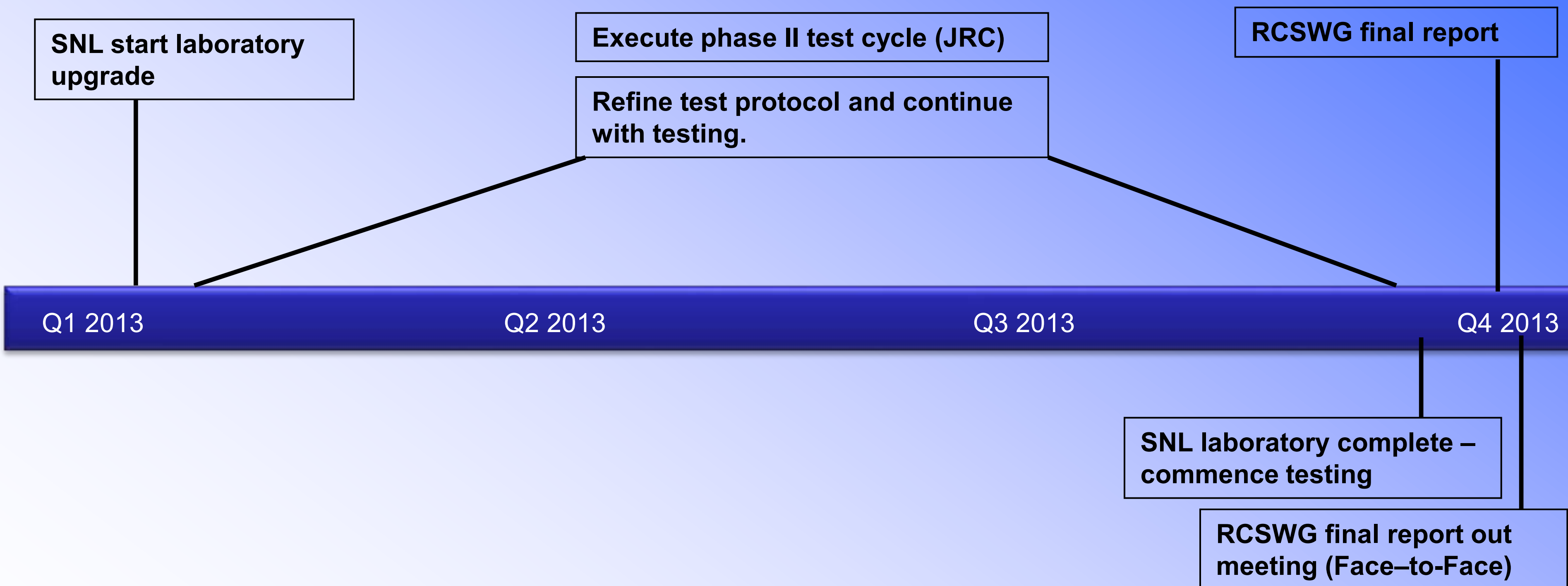
RCSWG RR Time Line - Pneumatic



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Member Countries

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

- **Note – Countries noted in dark blue are the most active**
- **Note – No contacts yet from Australia, Iceland, South Africa and South Korea**

Next Steps

- Face-to-Face Meeting in Washington DC in conjunction with the DOE/FCT AMR
  - Discuss status and progress of the RR on tank testing
    - A focus on hydraulic testing
    - A discussion on pneumatic testing
  - A discussion on the outcome from the Fuel Quality stack testing Task Force
  - Standing agenda item to discuss release events

Thanks to the US/DOE FCT Office for the official endorsement of ICHS-5 2013