



# ***IPHE Regulations Codes and Standards Working Group - Type IV COPV Round Robin Testing***

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# 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:

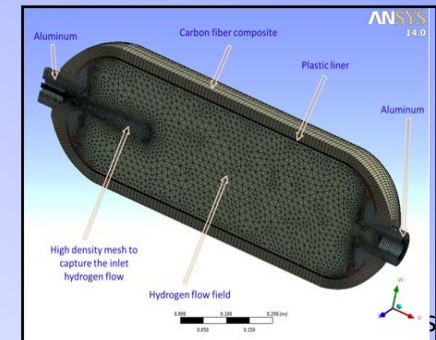
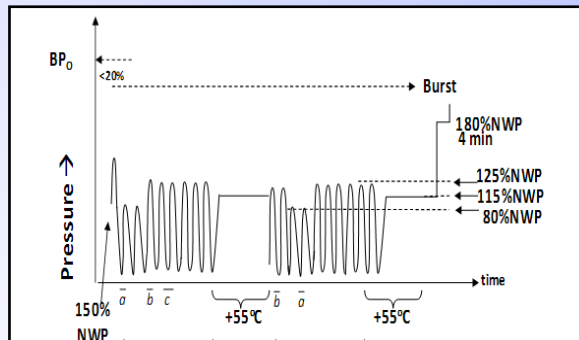
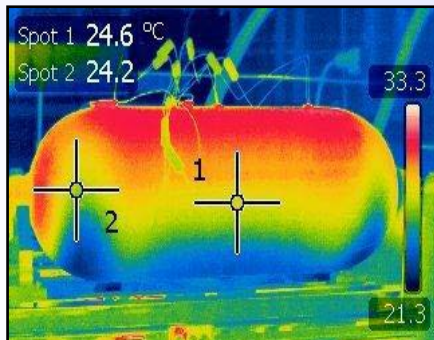
- A Round Robin (RR) to define a harmonized test measurement protocol.





# Type IV Tank Testing Round Robin

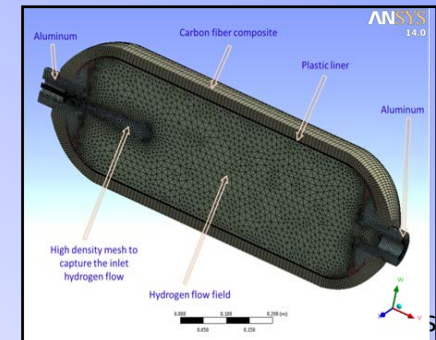
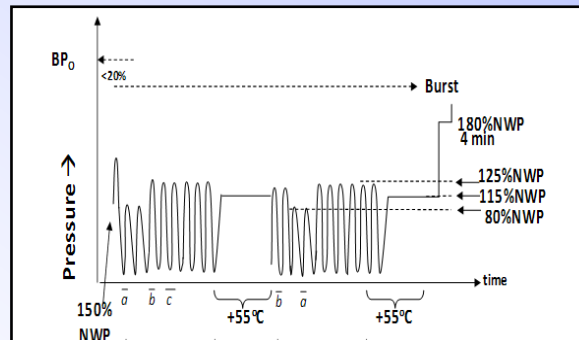
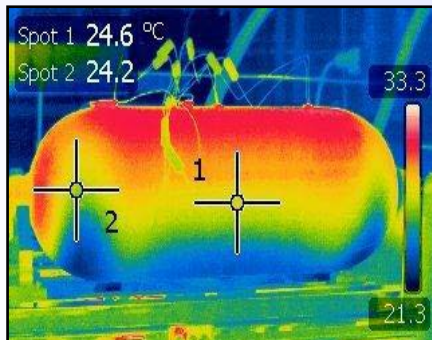
- September 2011:
  - Launched a multi-phase Round Robin (RR) testing program for Type IV COPVs (*Japan, UK, Brazil, EC, France, Canada, China, U.S.*)
- Phase I:
  - Defined a unique test protocol patterned after SAE J2579, GTR, and EIHP rev12b.



# Type IV Tank Testing Round Robin

## ➤ Phase II:

- 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 2<sup>nd</sup> tank



# Flow Configuration Zhejiang University

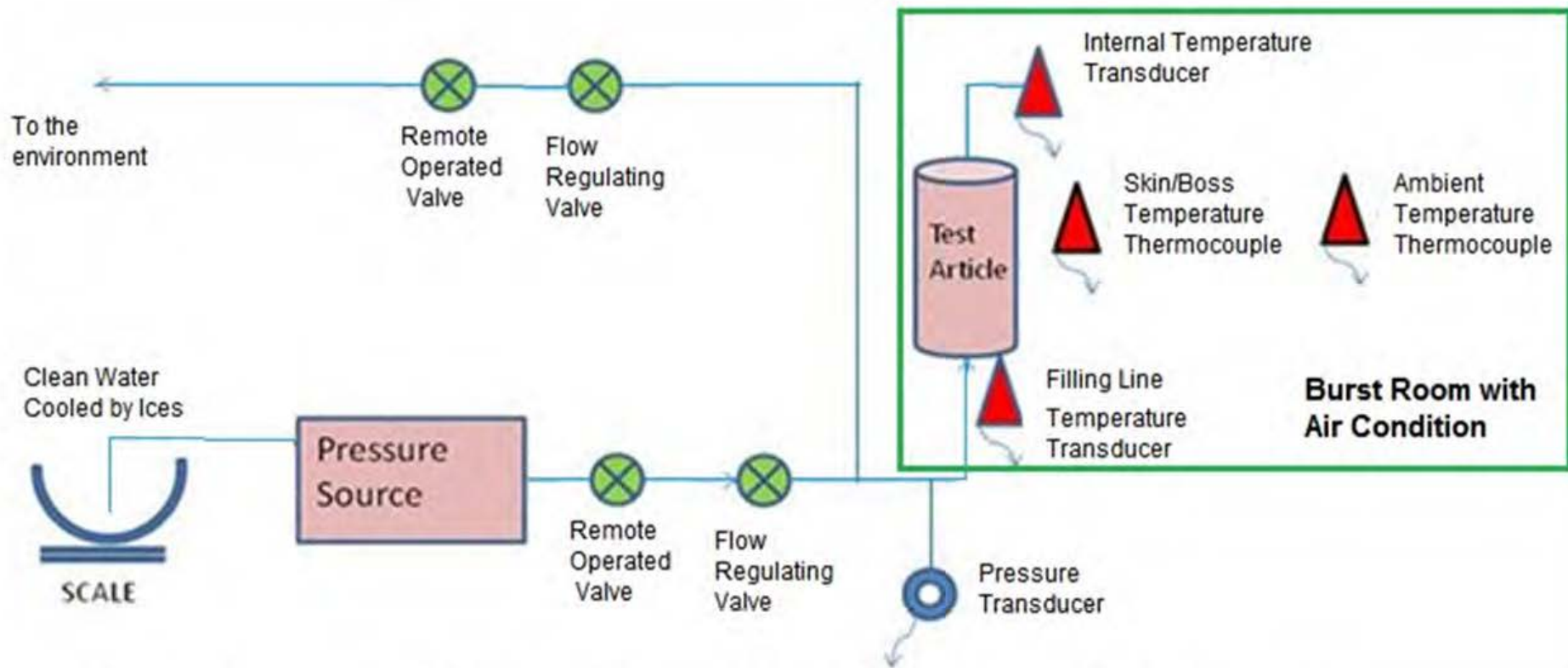


Figure 3 - Zhejiang Test and Measurement System Block Diagram



# Flow Configuration WSTF

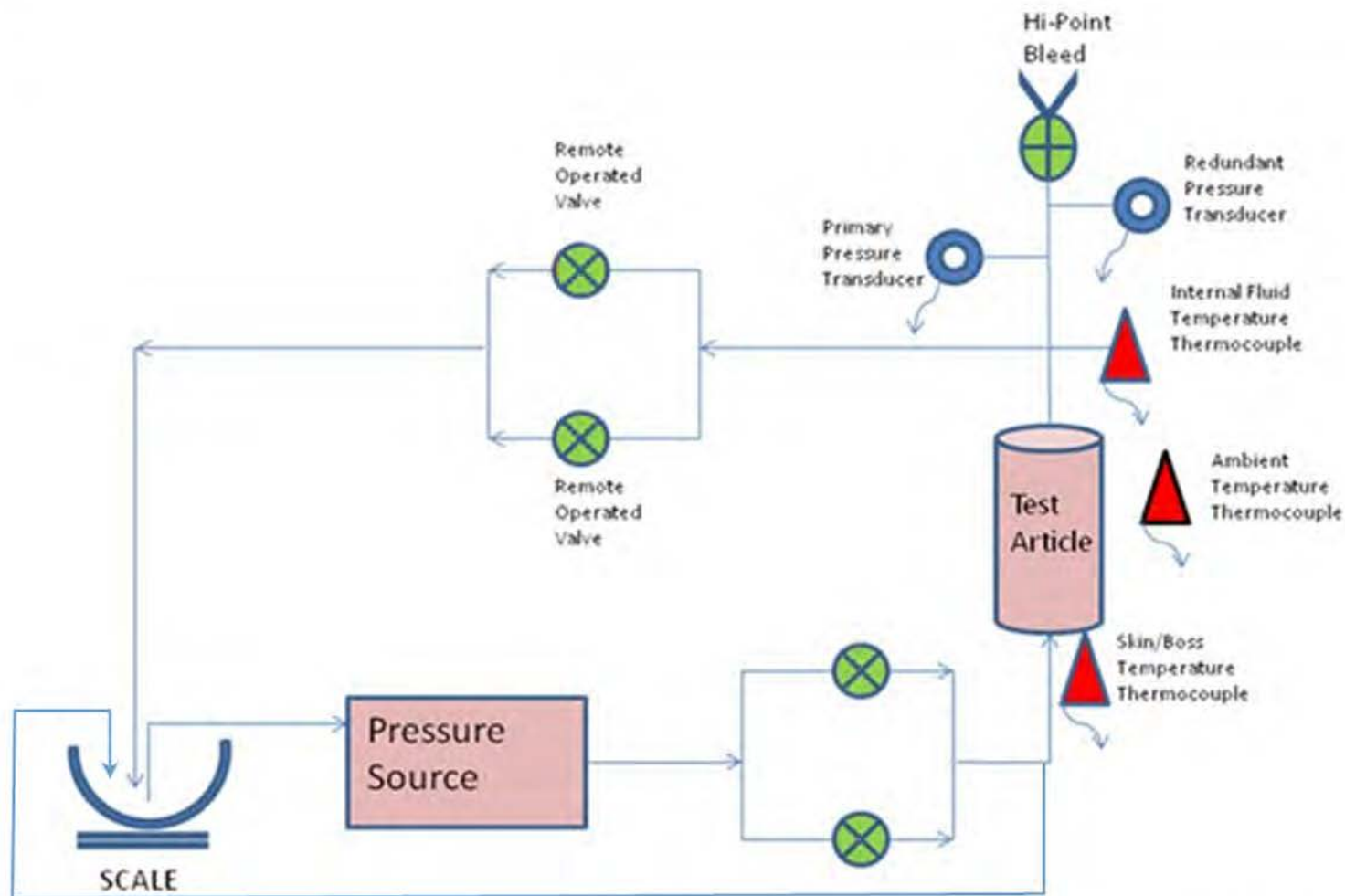
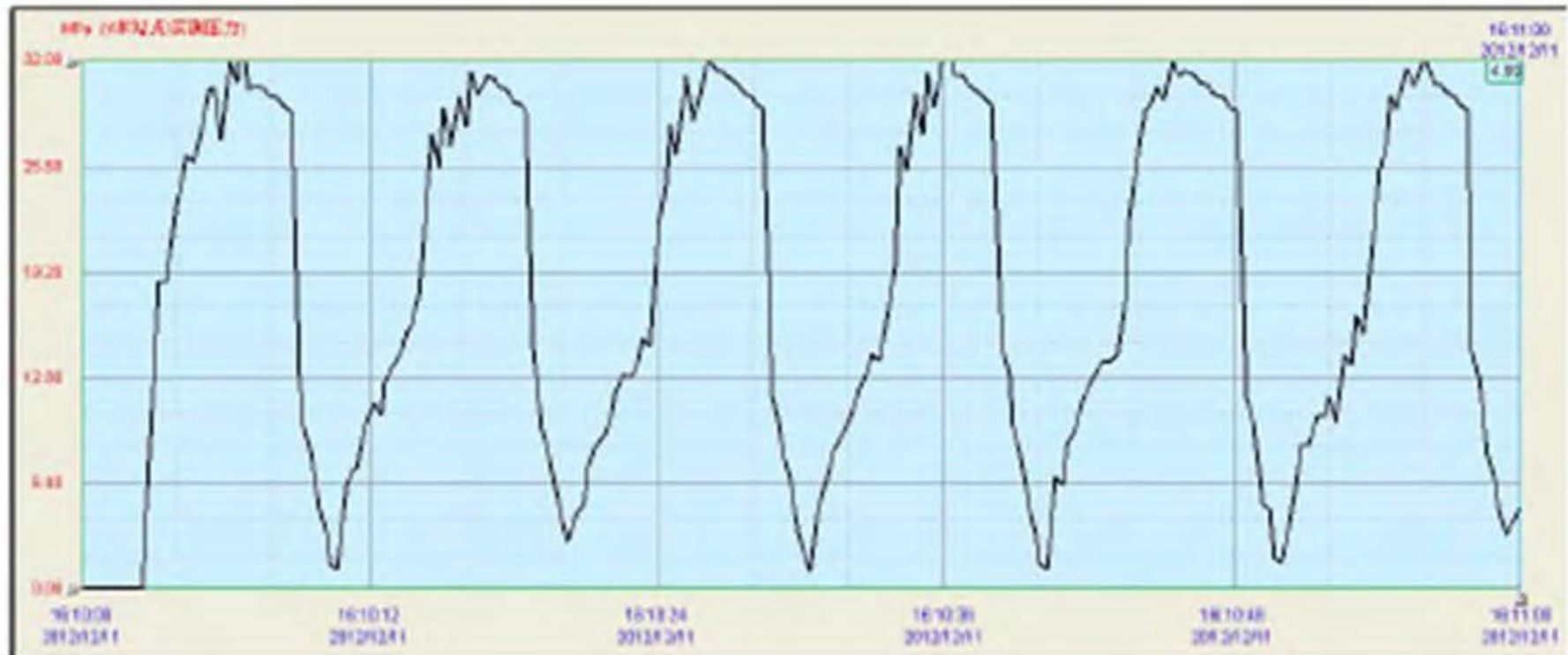


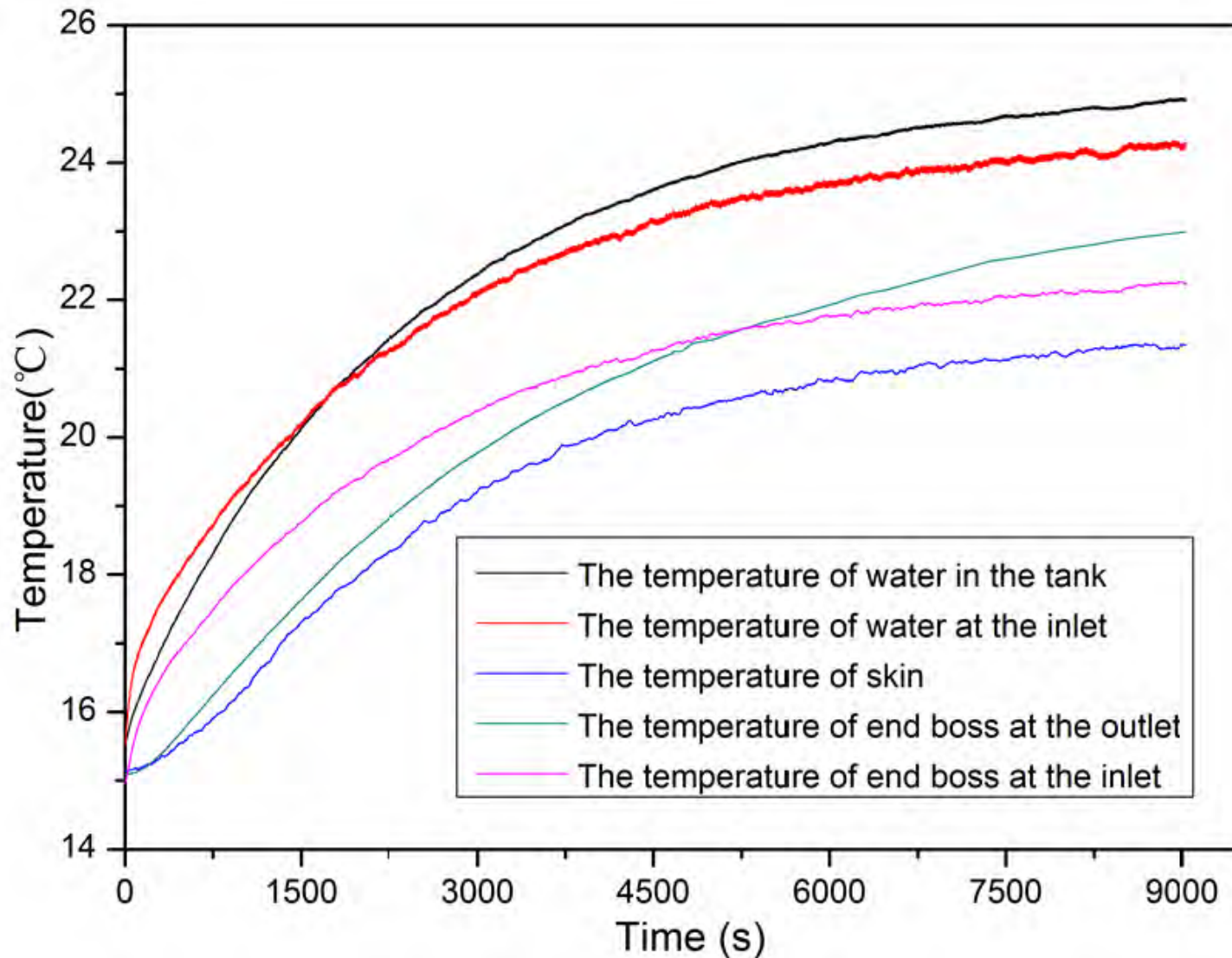
Figure 7 - NASA-WSTF Test and Measurement System Block Diagram

# Typical Pressure Cycle Zhejiang University



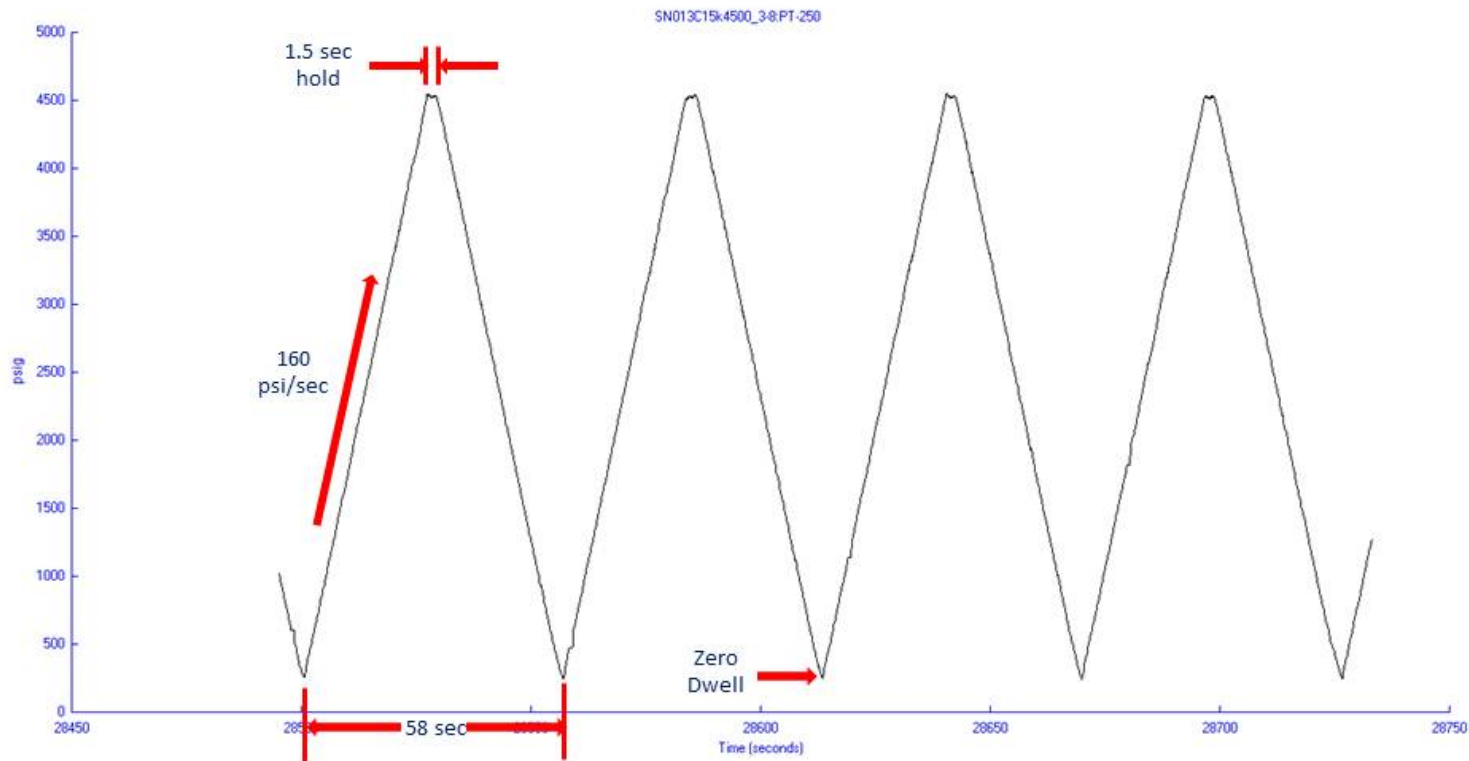
**Figure 13: Typical Zhejiang University Pressure Profiles (6 cycles/min)**

# *Temperature Variations as a Function of Time (Zhejiang University)*



# Pressure Profile (WSTF)

## Typical Pressure Profile (1 cycle per min)

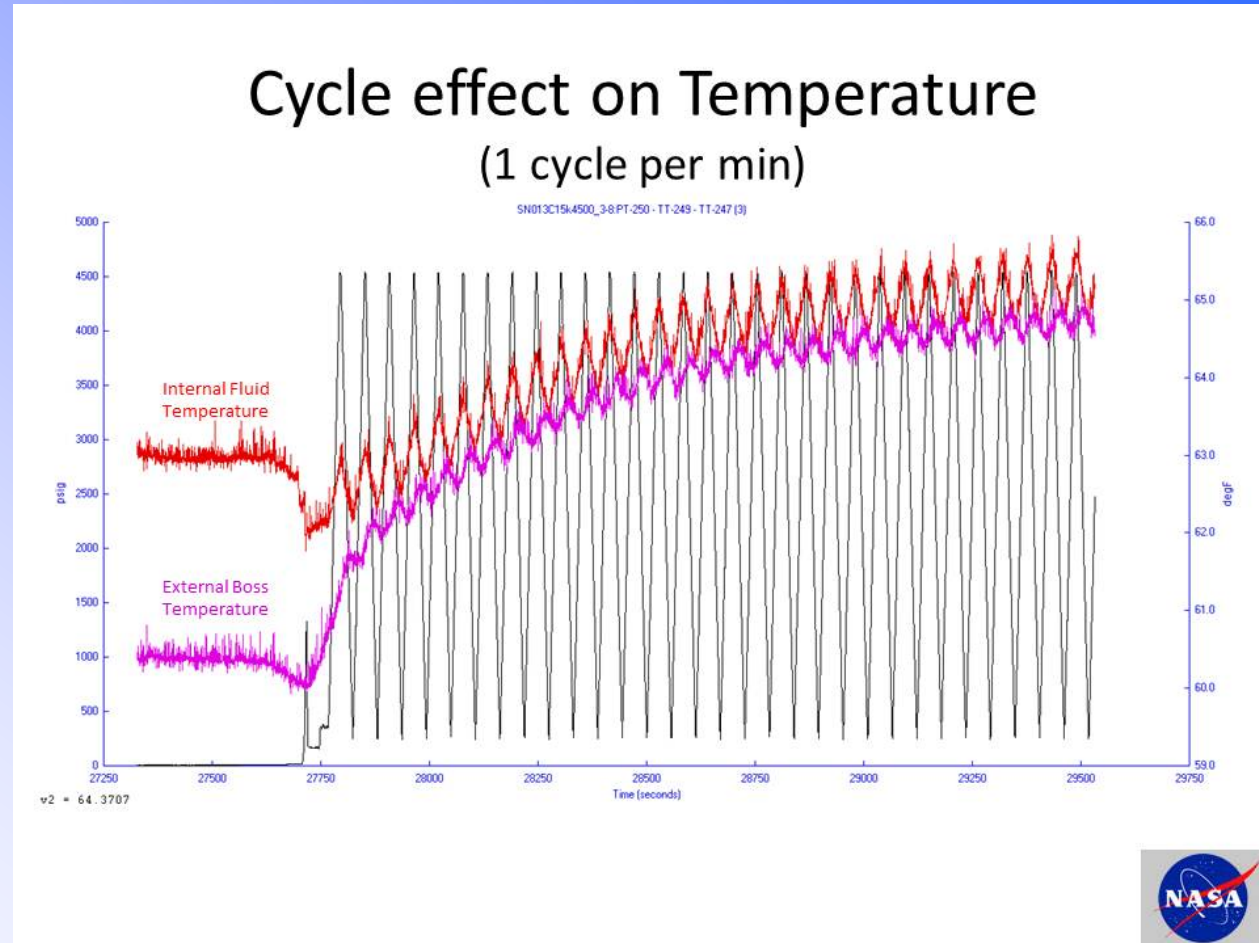




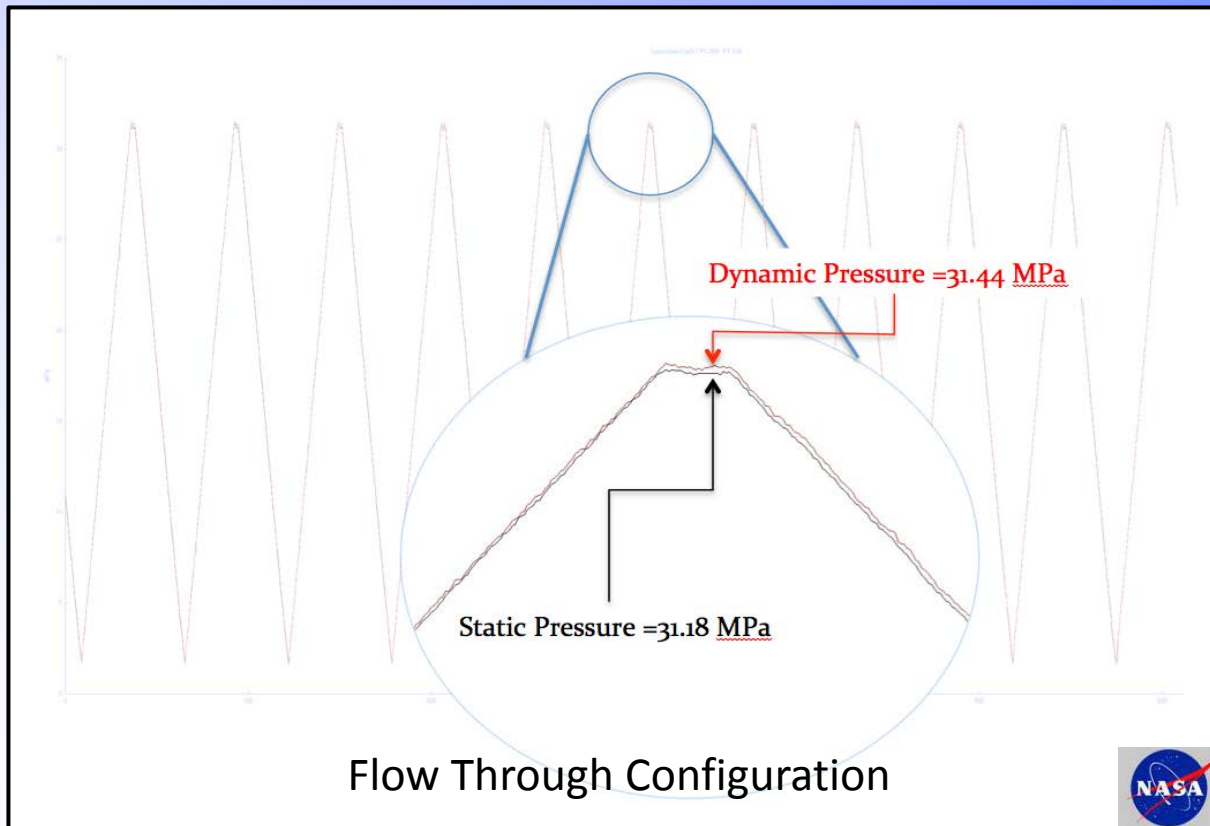
# Cycle Temperature Open Ended

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



# Dynamic Head vs Static Pressure



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

# Temperature Profiles vs Flow Configuration

1 cycle/min

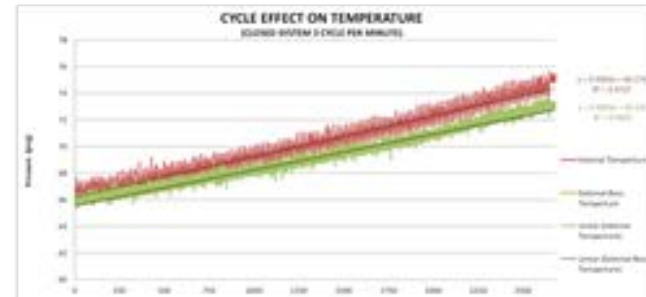
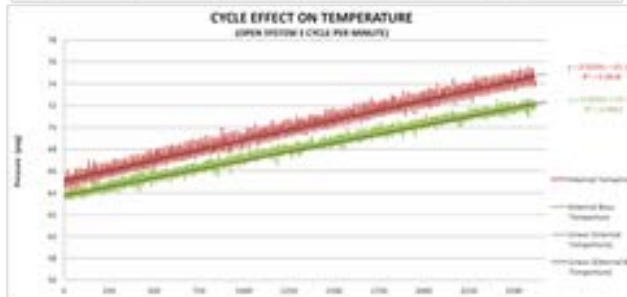
Flow-Through



Dead-ended

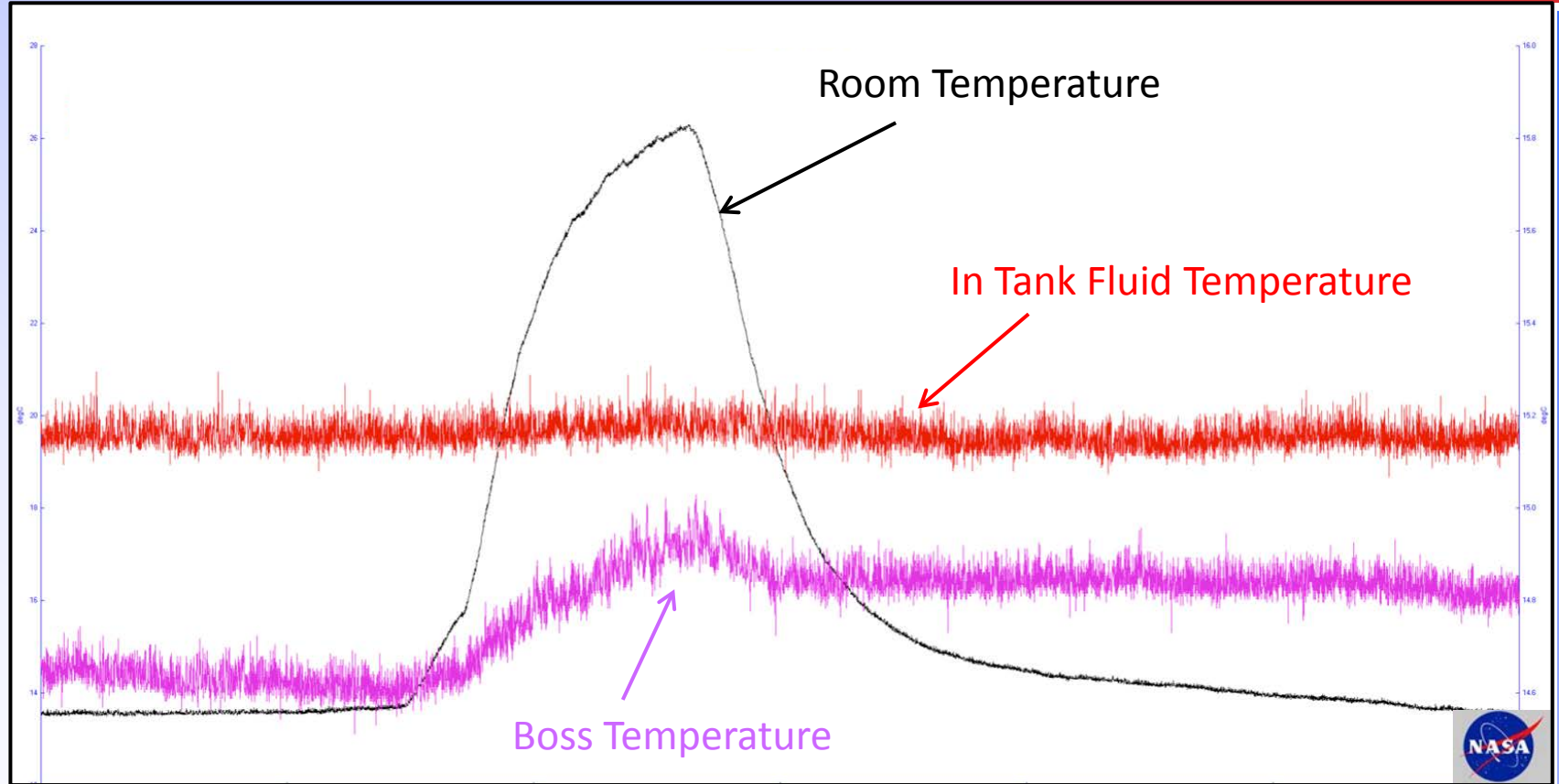


3 cycle/min



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

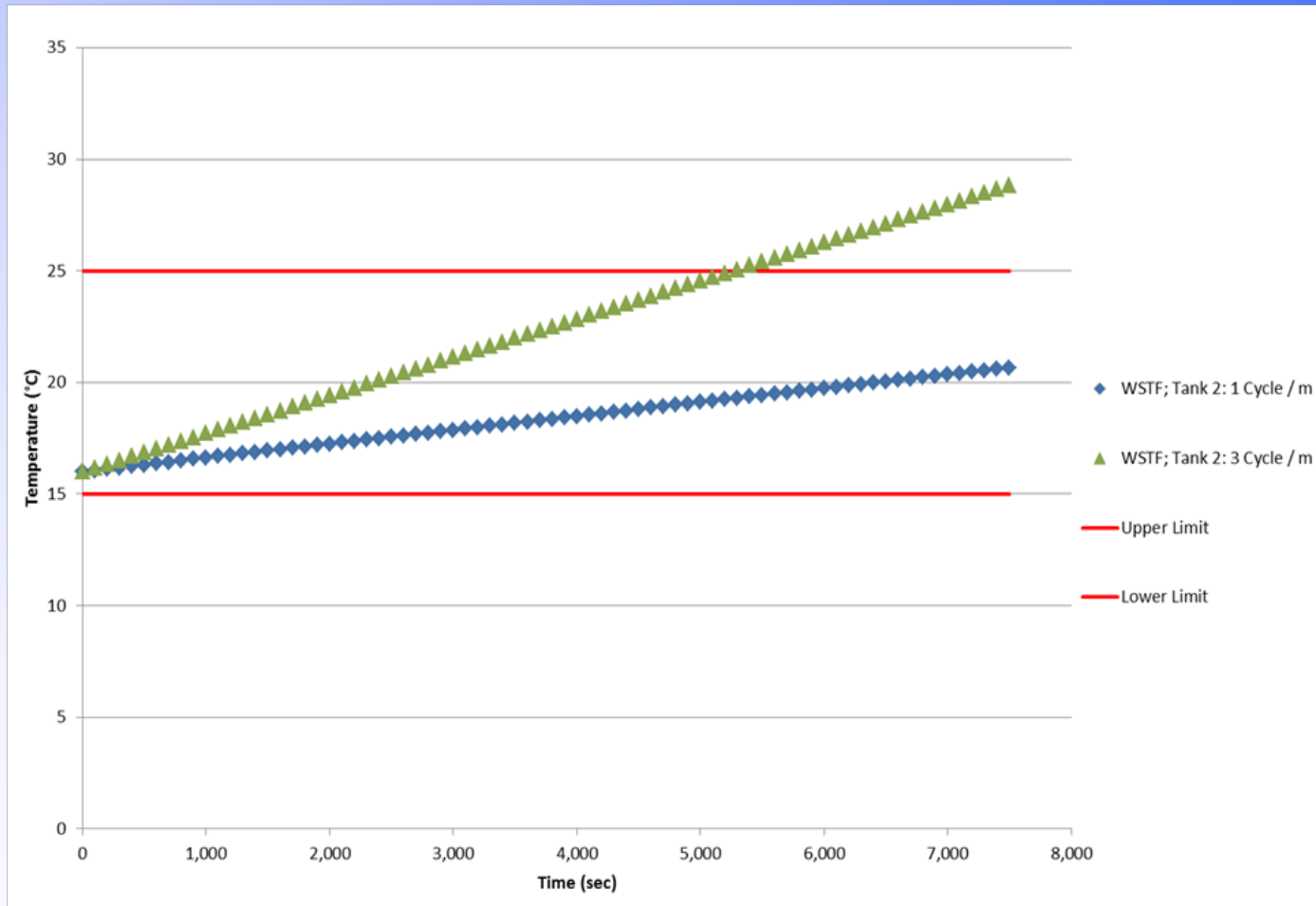
# Room Temperature Effects on In Tank Fluid Temperature



- 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



# *In Tank Temperature vs Time*



**Figure 21: Comparison of temperature versus time for the NASA-WSTF configuration.**

# *In Tank Temperature vs Cycle*

➤ Temp. increase is system dependent

- Temp. increase on a per cycle basis is roughly independent of cycle rate (everything else being constant)
- Upper temperature limit reached after about ~250 cycles

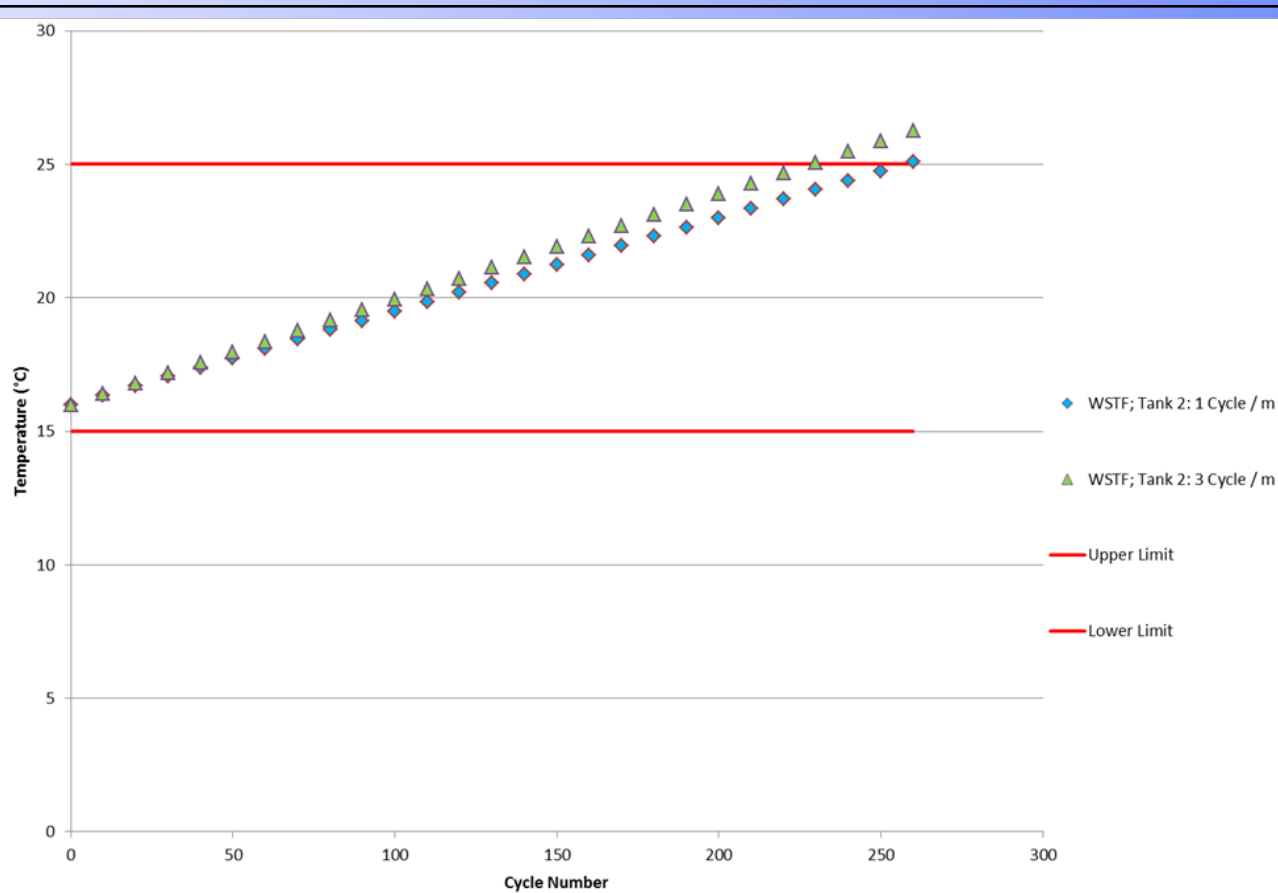


Figure 22: Comparison of temperature versus cycle number for the NASA-WSTF configuration.

# Summary

- Test Method Protocol Defined
  - Based on proposed test sequences(i.e. SAE J2579, GTR, EIHP Rev 12B)
- Successfully executed the protocol with similar results at two locations in the second trial
- The most difficult parameter to control was working fluid temperature in the tank
- In tank temperature increases per cycle almost independent of cycle frequency.
  - Is system dependent
- A carefully designed pass thru configuration with external temperature control enabled continuous operation.

Thank you.





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

## IPHE RCSWG Meeting

September 12, 2013

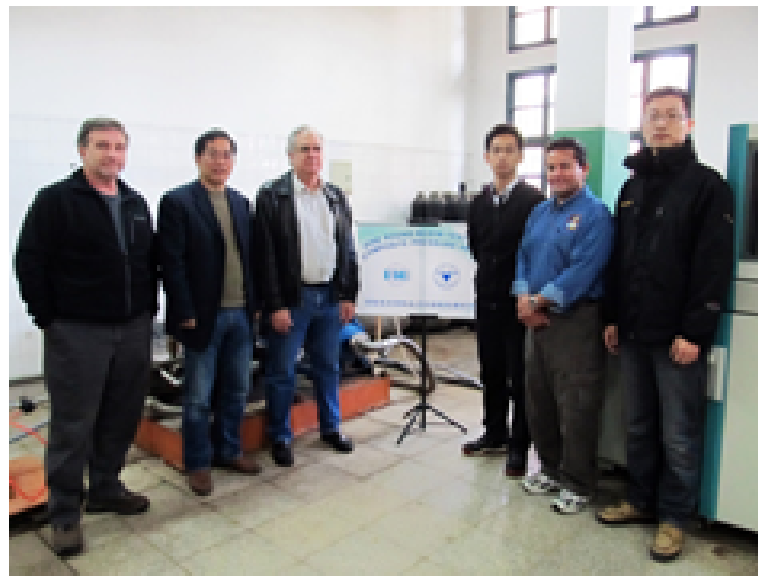
Brussels - Belgium

### 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**.



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