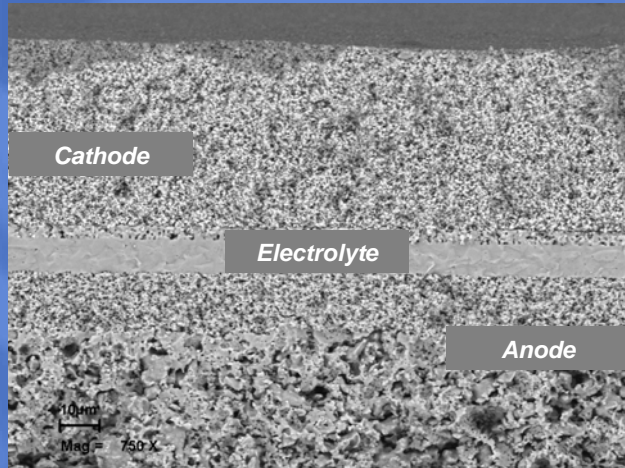


Versa Power Systems Stack Testing Summary

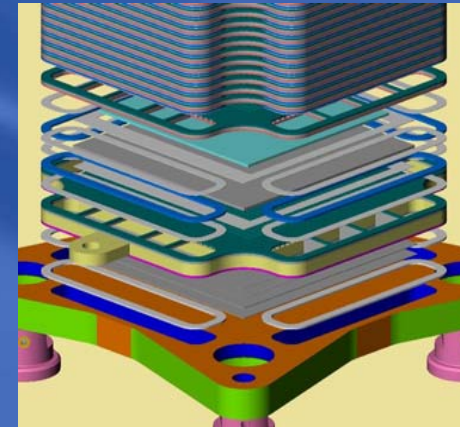
Jason Dueck

SOFC X, Nara, Japan

4 June 2007



- Anode supported cells
- Uncoated ferritic stainless steel sheet metal interconnect
- Cross-flow fluid delivery with manifolds integrated into the interconnect but not through the cell
- Compressible ceramic gasket seals





Cell Active Area = 121 cm²

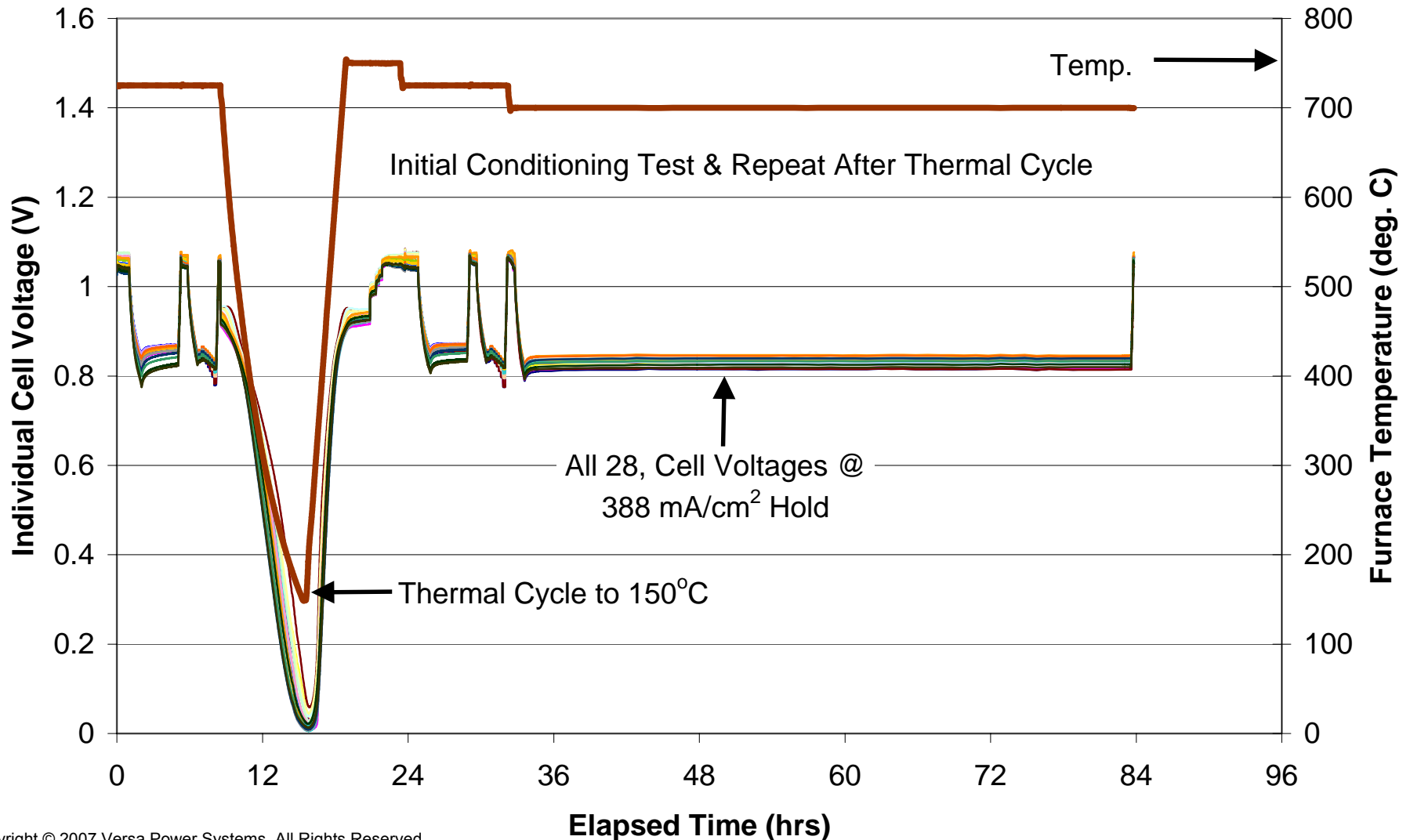
Number of Cells = 28

Power output = 1.0 kW

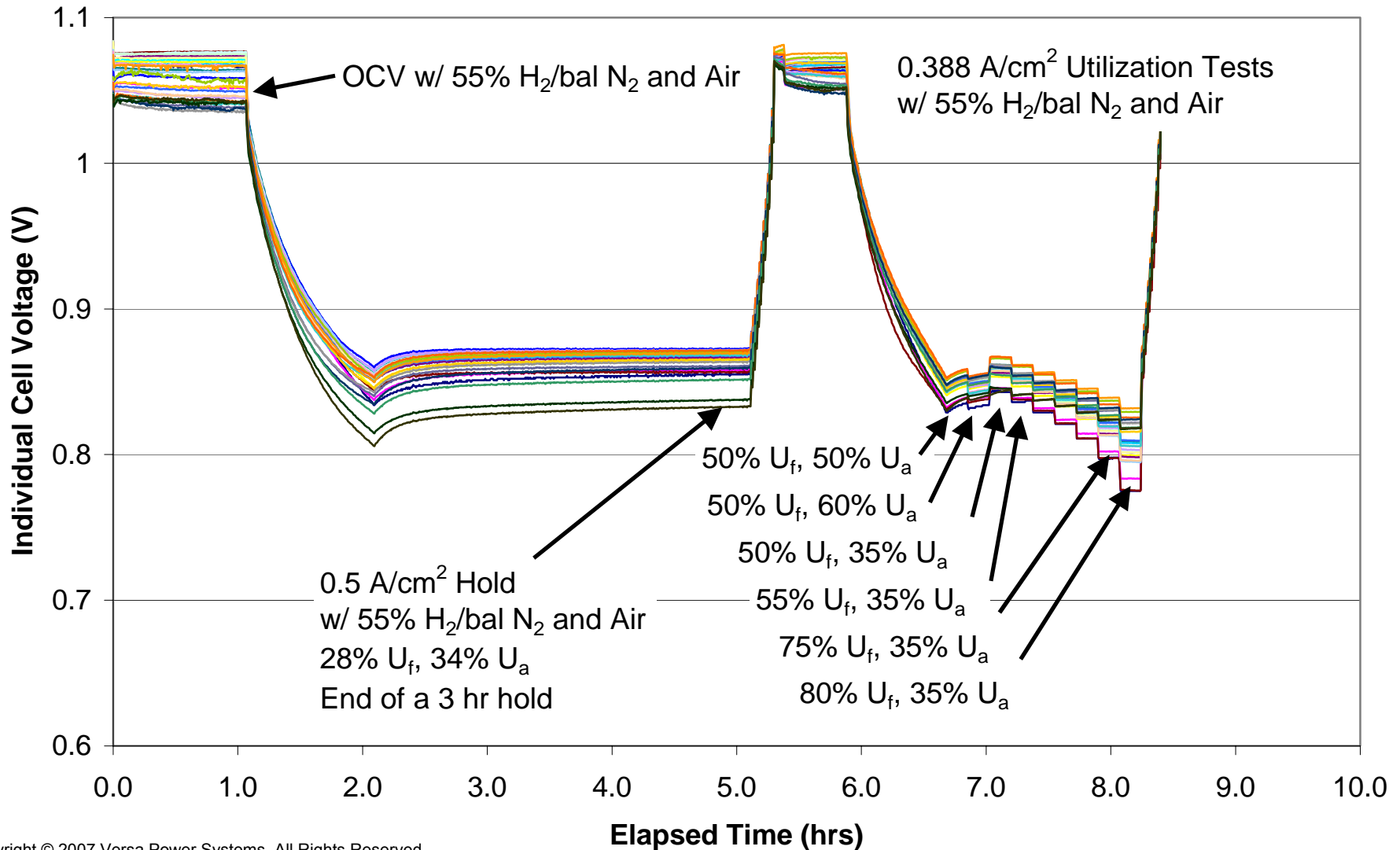
- **Stack Testing at Versa falls into 3 categories**
 - **Standard testing that focuses on the initial qualification of a stack**
 - **Long-term degradation testing which studies voltage degradation over time**
 - **Thermal cycle testing that focuses on the voltage loss that occurs over multiple thermal cycles**



GT056019-0087 - 28 Cell Stack 28-Aug-06, 3% H₂O



GT056019-0087 - 28 Cell Stack - TC1
31-Aug-06, 3% H₂O



Condition Description	Conditions	Requirement
Open Circuit Voltage	1.65 slpm/cell H ₂ , 1.35 slpm/cell N ₂	All cells > 1.01 V
Full Flows, 0.5A/cm ²	28% U _f , 34% U _a , 0.5 A/cm ² , 725°C	All cells > 0.8 V
Air Utilization	50% U _f , 60% U _a , 0.388 A/cm ² , 725°C	All cells > 0.7 V
Fuel Utilization	75% U _f , 50% U _a , 0.388 A/cm ² , 725°C	All cells > 0.7 V
Thermal cycle Degradation	Each condition is compared before and after the thermal cycle at 0.5 A/cm ² and 0.388 A/cm ²	No cell degradation > 0.006V

****Stacks must meet these minimum requirements to proceed to other testing***

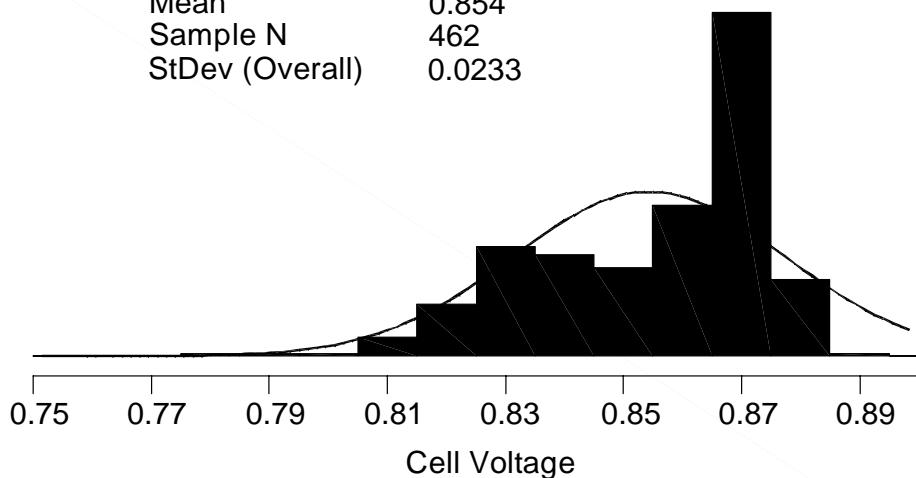
Overview of Internal Testing Results - Initial Performance Summary -

2004 - 2005

Process Capability - 21 Cell Stacks
Based on 22 Stacks - 462 Cells

Process Data

Mean	0.854
Sample N	462
StDev (Overall)	0.0233

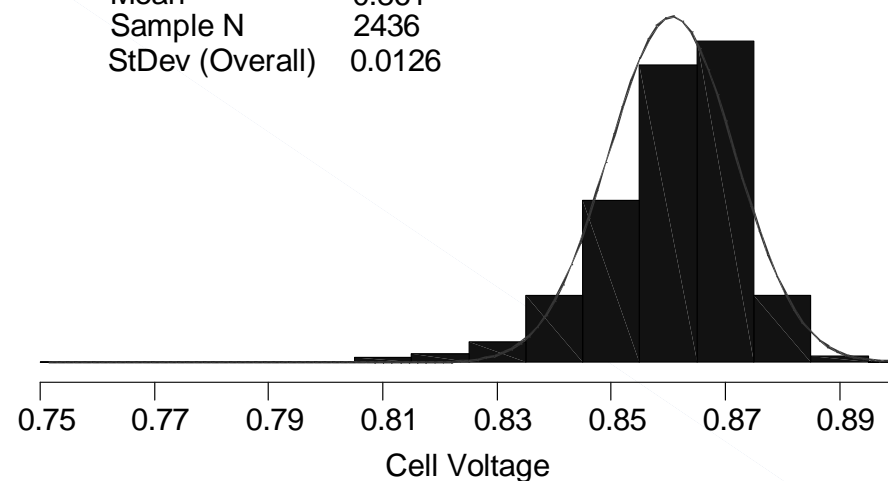


2005 - 2006

Process Capability - 28 Cell Stacks
Based on 87 Stacks - 2436 Cells

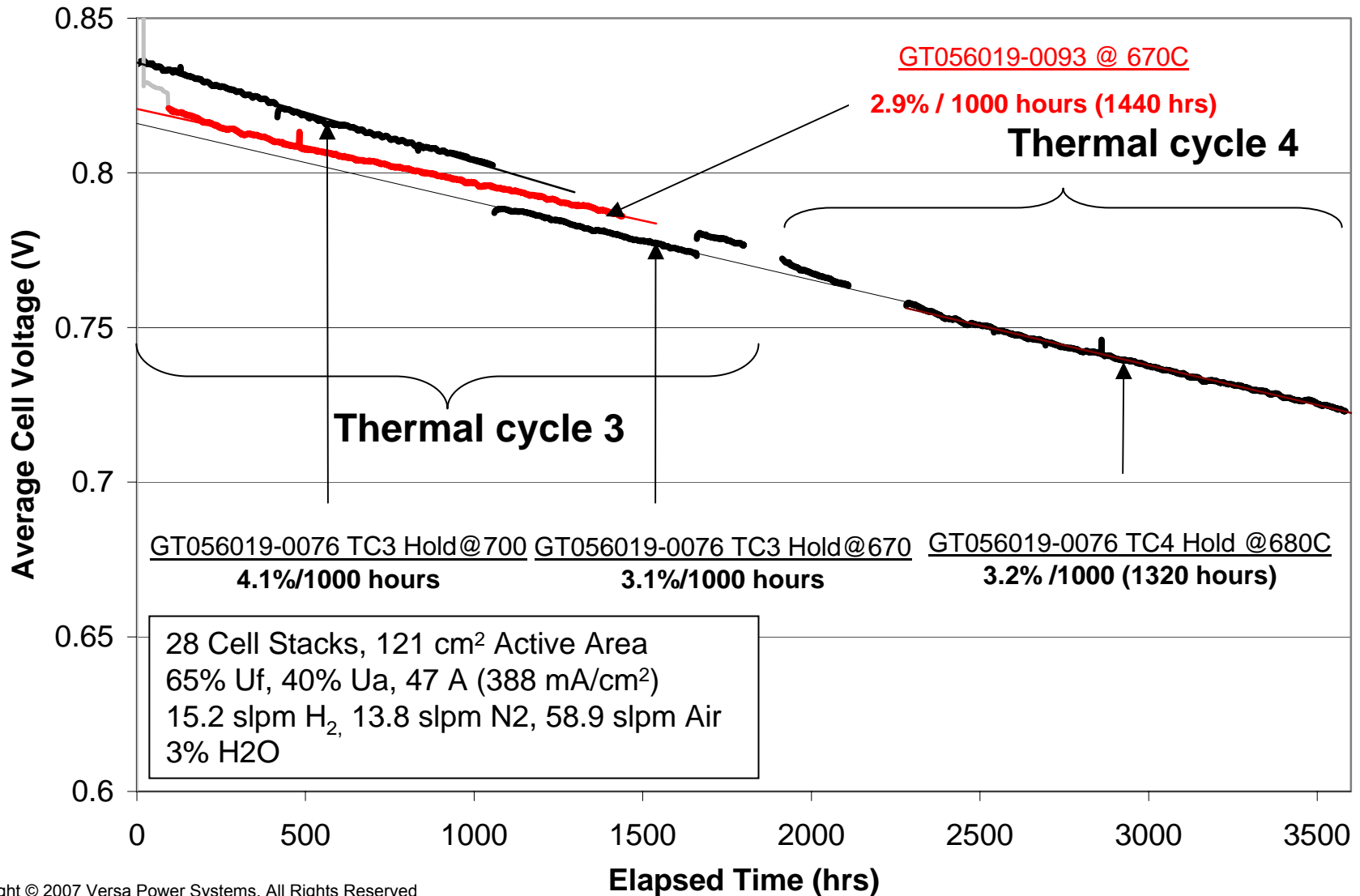
Process Data

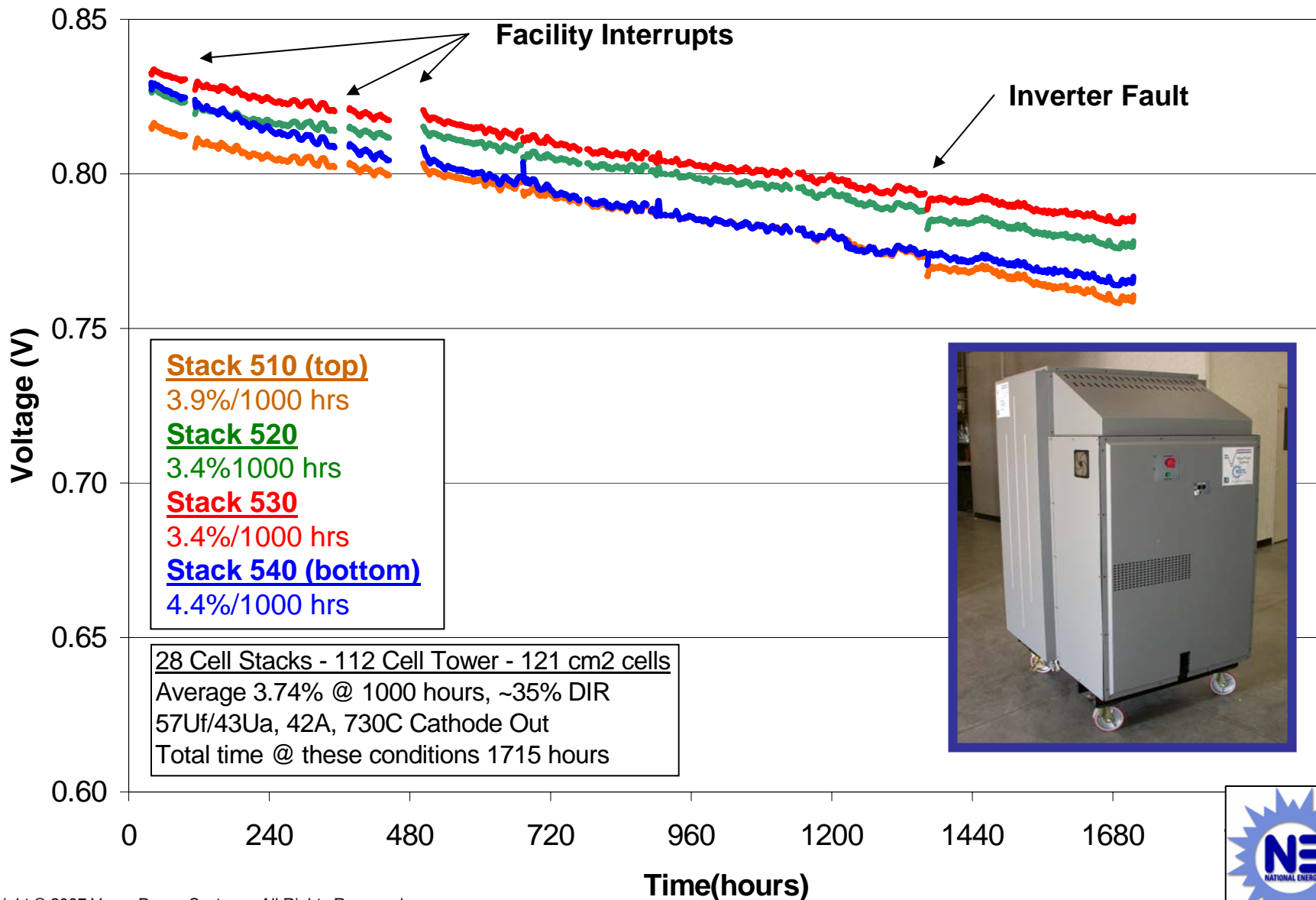
Mean	0.861
Sample N	2436
StDev (Overall)	0.0126

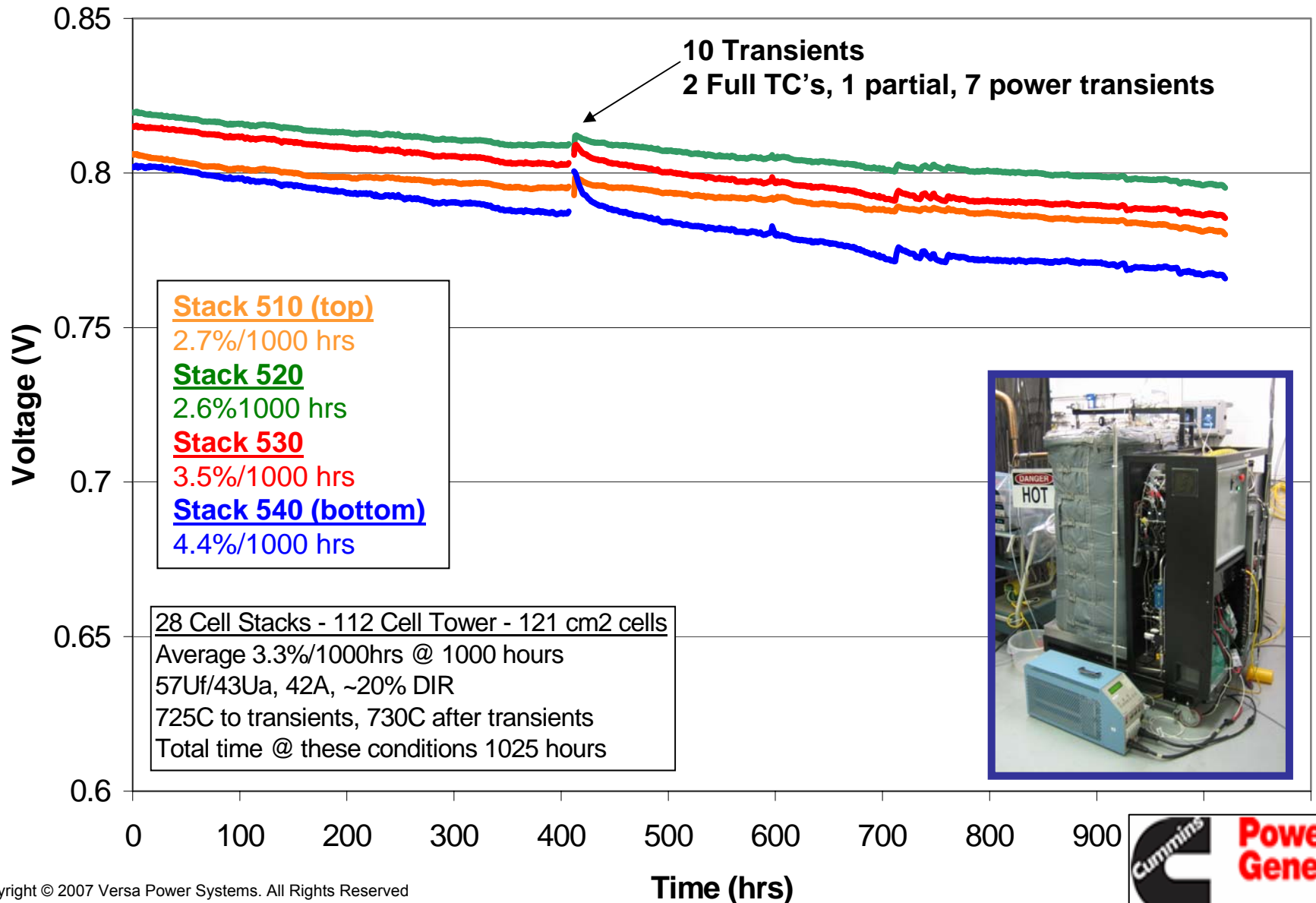


**The analysis shows an increase average cell voltage by a statistically significant 7 mV during the scale up from 21 to 28 cell stacks.*

GT056019-0076 & 0093 Long-term Holds



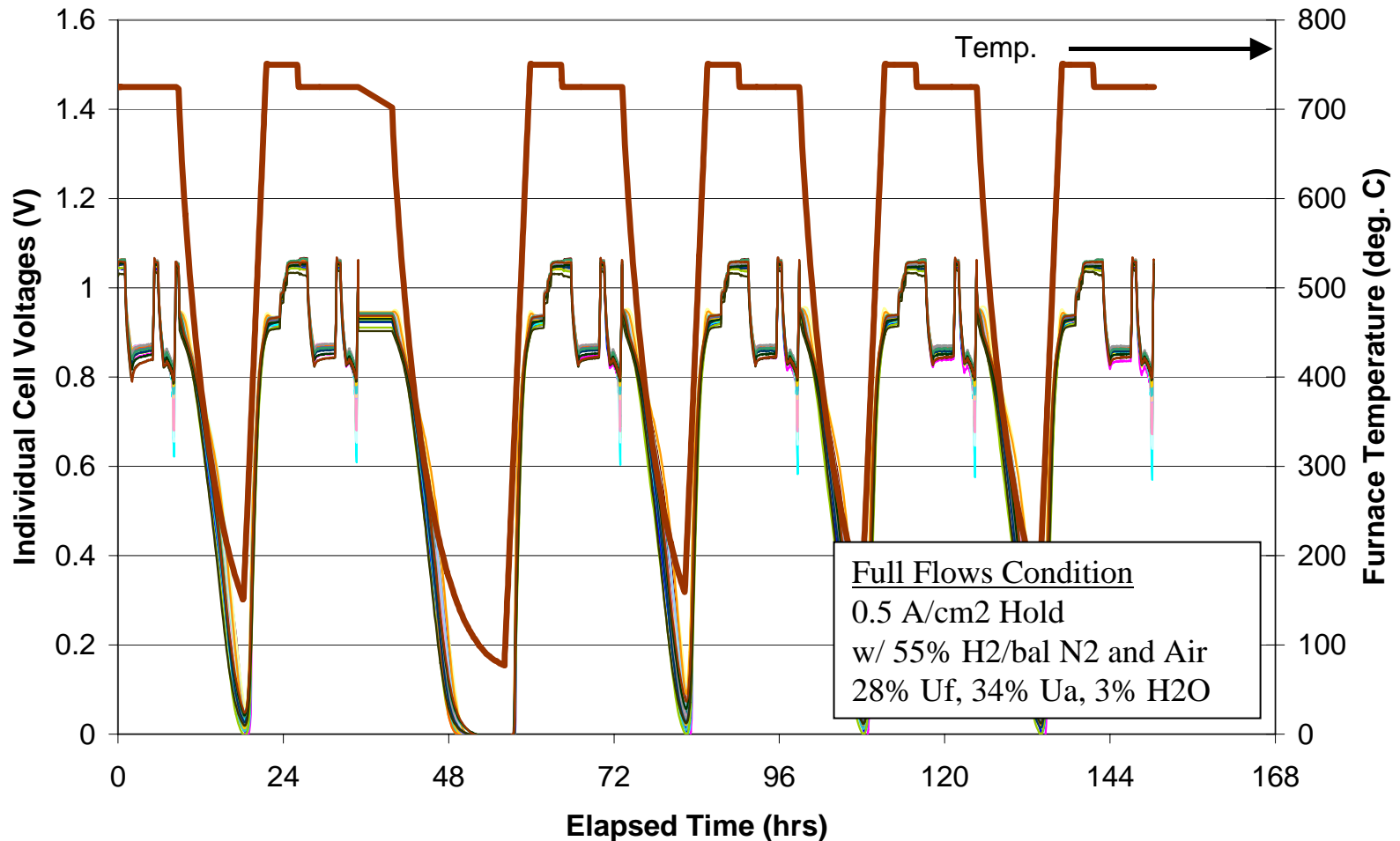




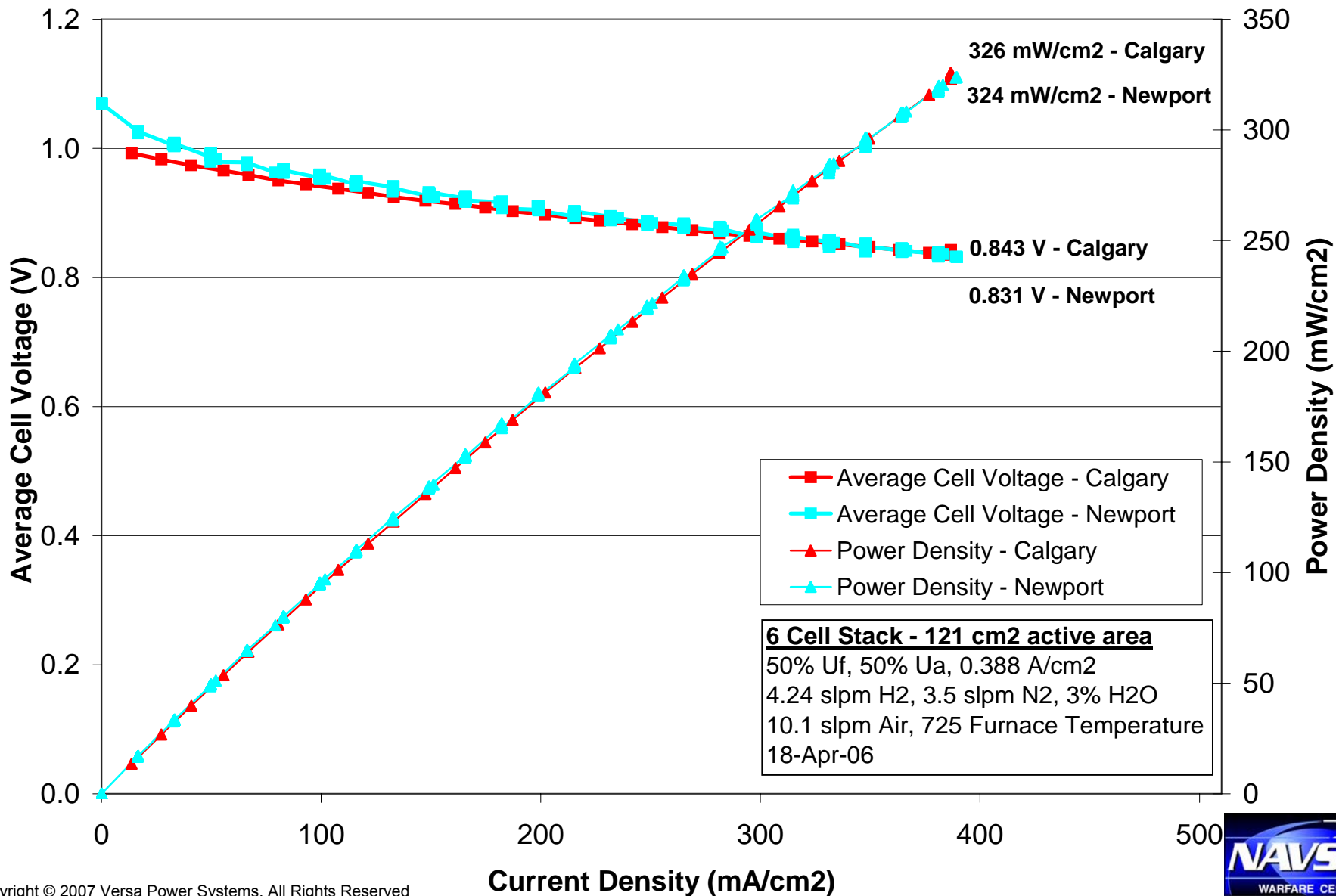
Thermal Cycle Testing

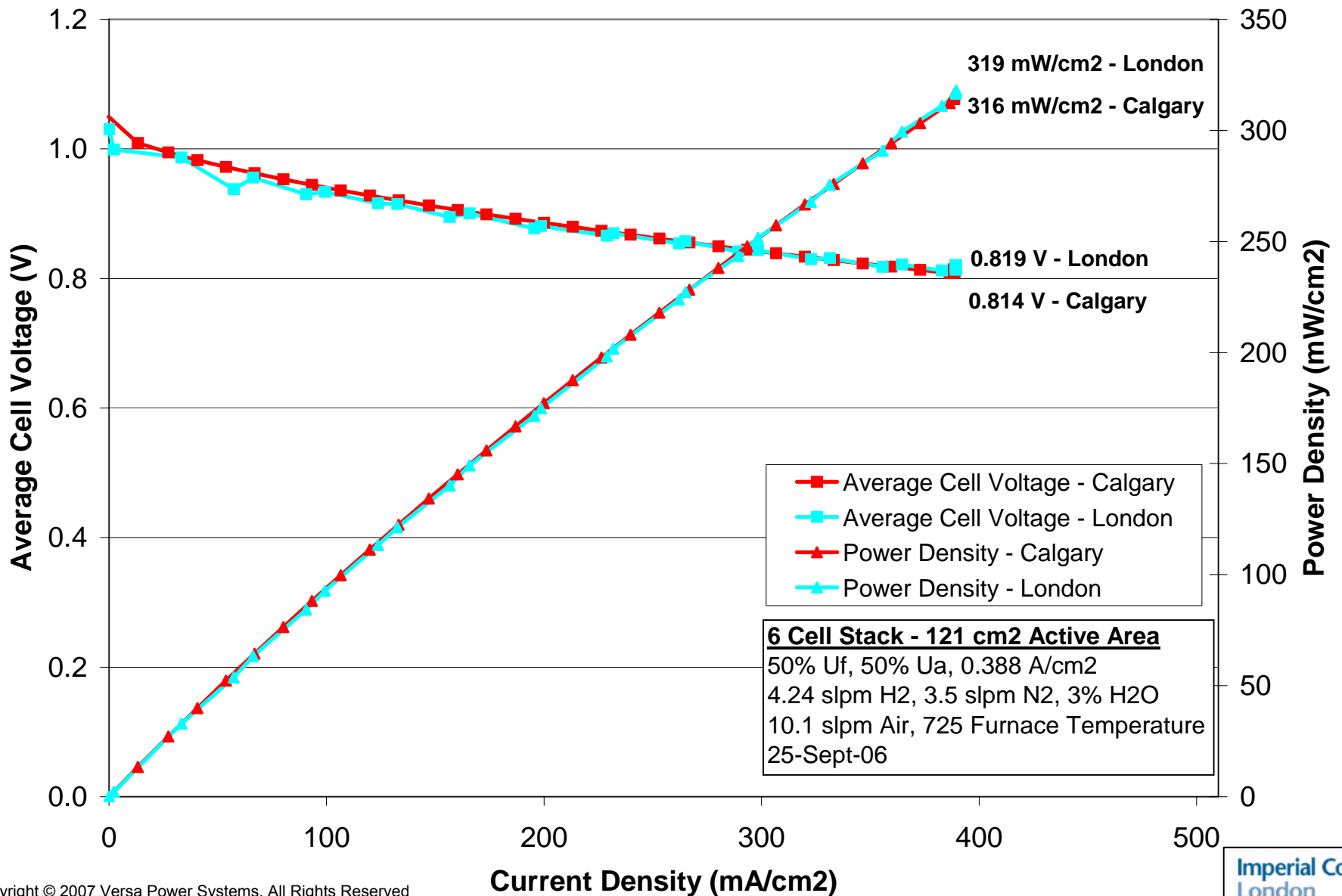
- VPS in Calgary, Alberta -

Thermal Cycle Degradation Results - 28 Cell Stack
121 cm² Active Area, GT056019-0053 9-May-2006



**The cell voltage degradation over 5 thermal cycles at 0.5 A/cm² was 0.5%*

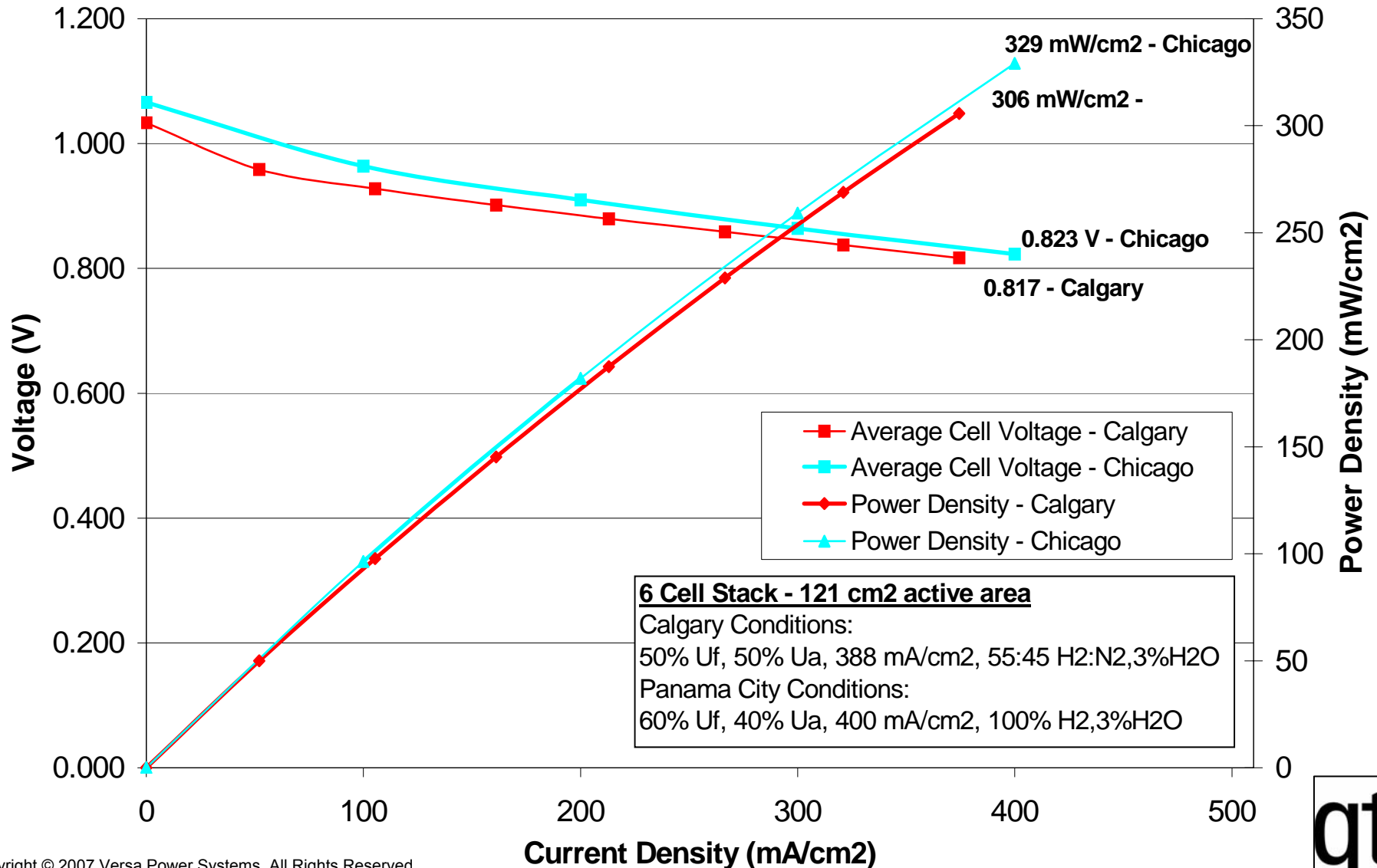




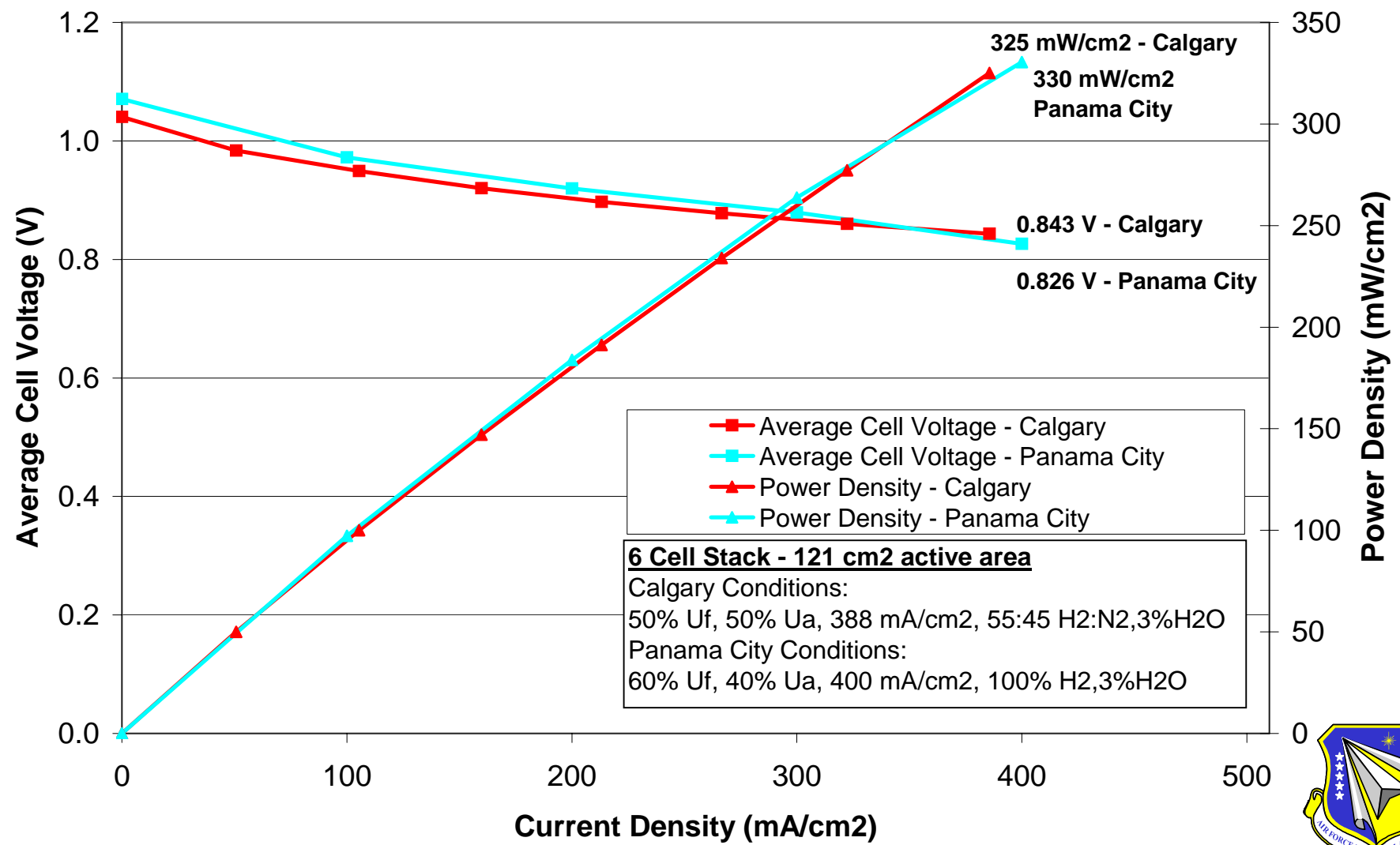


Gas Technology Institute – Chicago, Illinois

- US Department of Defence Program – Logistical Fuels -



AFRL SOFC Testing - H2 Performance Testing VPS-21 Cell Stack - 121 cm² active area - 25-May-05



- VPS utilizes an internally manifolded, anode supported SOFC stack
- Stack Development is reliant on **standardized testing** that allows statistical analysis tools to be used to direct stack and stack component development
- **Repeatable testing results** have been demonstrated internally, in system and these results have been externally verified by the US Naval Underwater Warfare Centre, Imperial College, Gas Technology Institute and the US Air Force Research Lab
 - Internal stack degradation rates for the VPS production stack are **2.9 to 3.1%/1000 hrs**
 - System Testing results yield comparable stack degradation rates of **2.6% to 4.4%/1000 hrs**
 - Stack Performance has been demonstrated within **+/- 2%** by 4 independent organizations at external sites – after being shipped using standard shipping methods



**Versa Power Systems Team
FuelCell Energy
Cummins Power Generation
U.S. Naval Underwater Warfare Center
Imperial College
Gas Technology Institute
U.S. Air Force Research Labs
U.S. Department of Energy
National Energy Technology Laboratory
(DOE / NETL) under Award Numbers
DE-FC26-04NT41837 (FCE)
DE-FC26-01NT41244 (CPG)**

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