

Solid Oxide Fuel Cell Development Status at Versa Power Systems

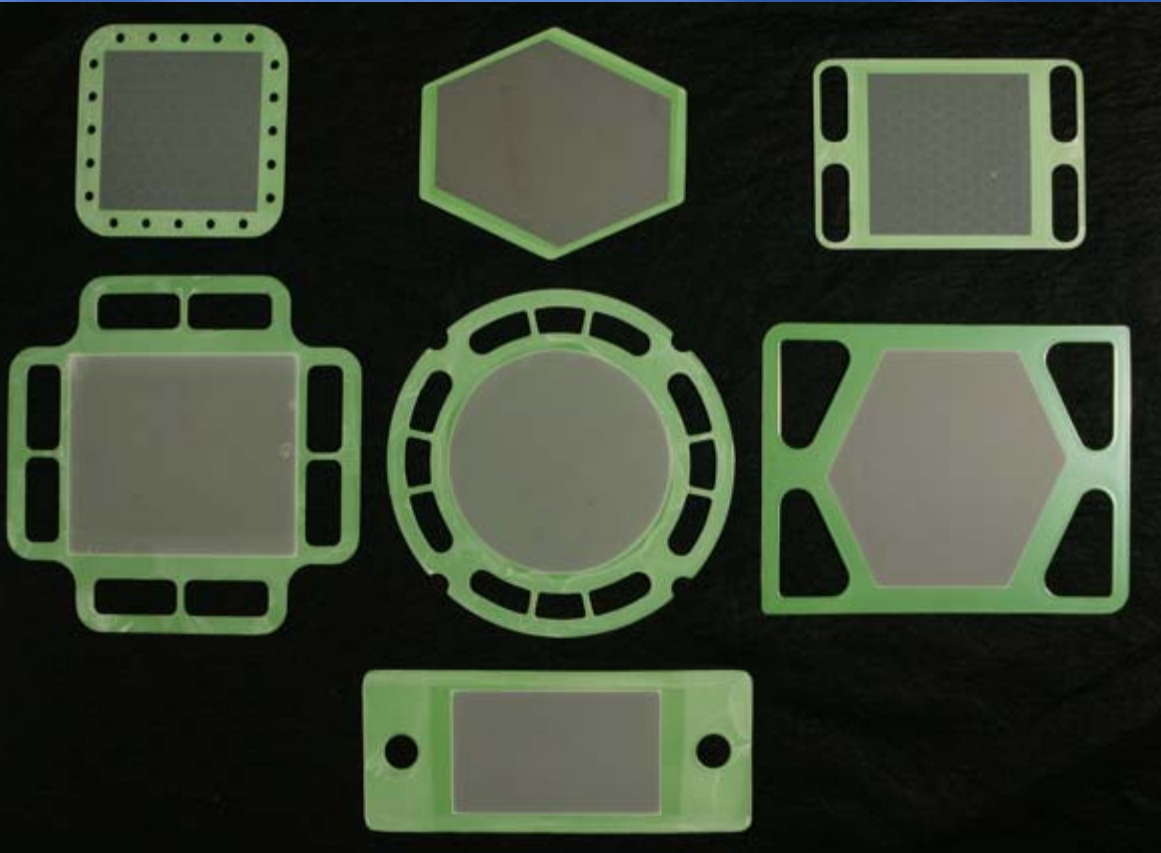
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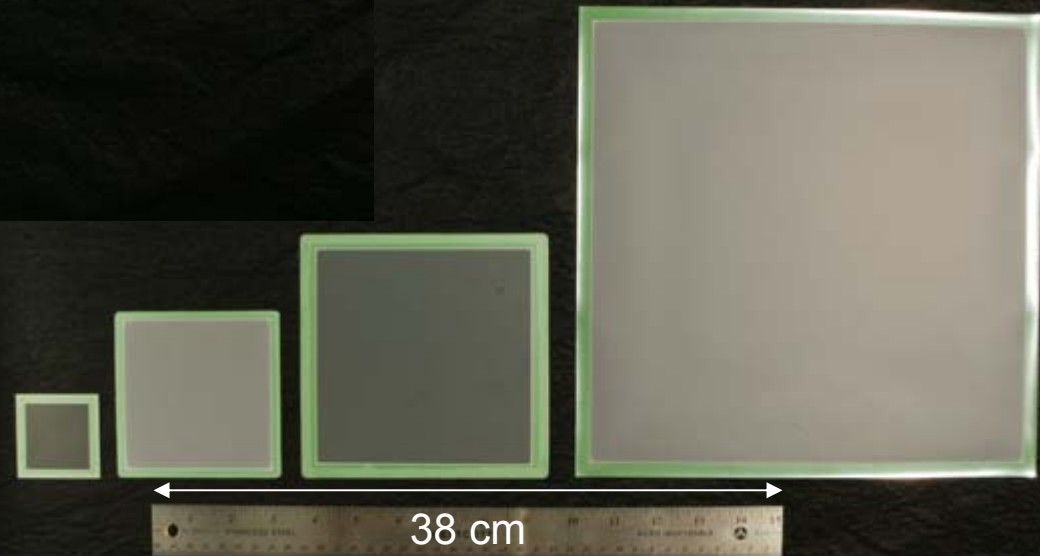
Recent Business Developments

- **Versa Power Systems is now the SOFC technology provider to two U.S. Department of Energy SECA programs:**
 - **FuelCell Energy**
 - **Cummins Power Generation**
- **The support provided by the U.S. DOE and these two program primes is acknowledged and gratefully appreciated**





**The Flexibility of the
Fabrication Process
Facilitates
Alternate Stack Design**





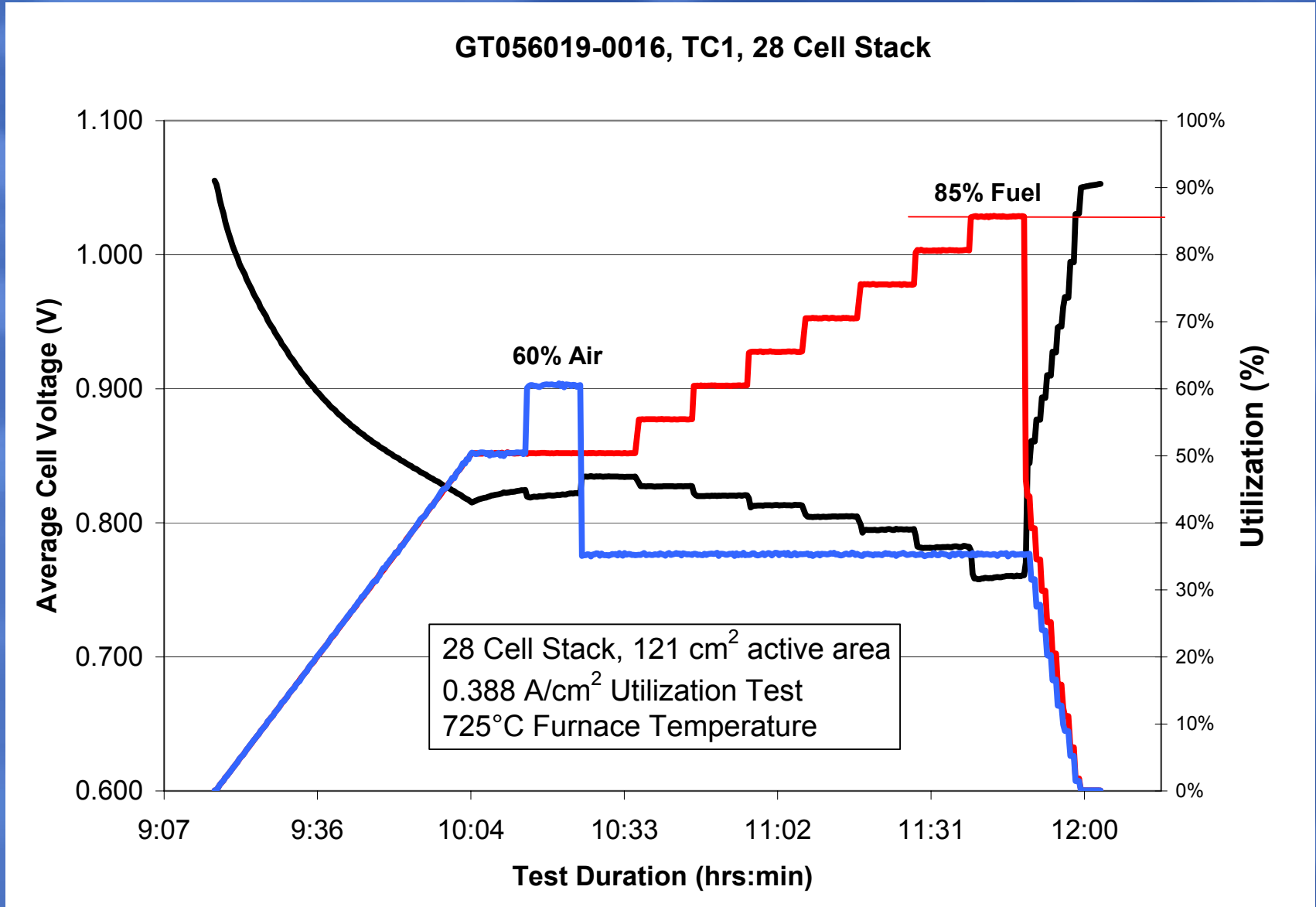
Stack Results

Present Stack Module



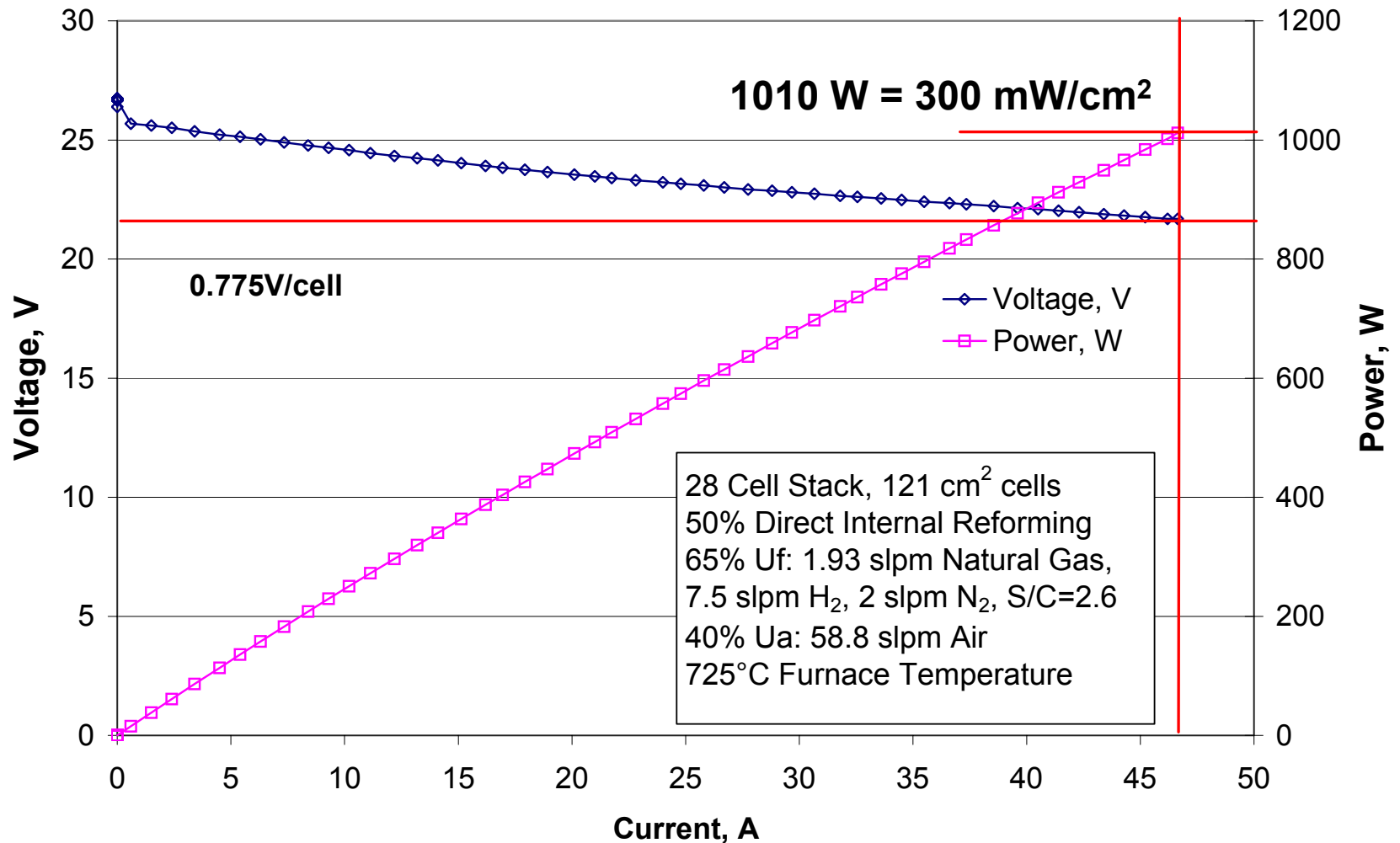
Cell Active Area (cm²)	121
Number of Cells	28
Gross Power (W)	1,152

Stack Performance: 28 x 121 cm² active area cells



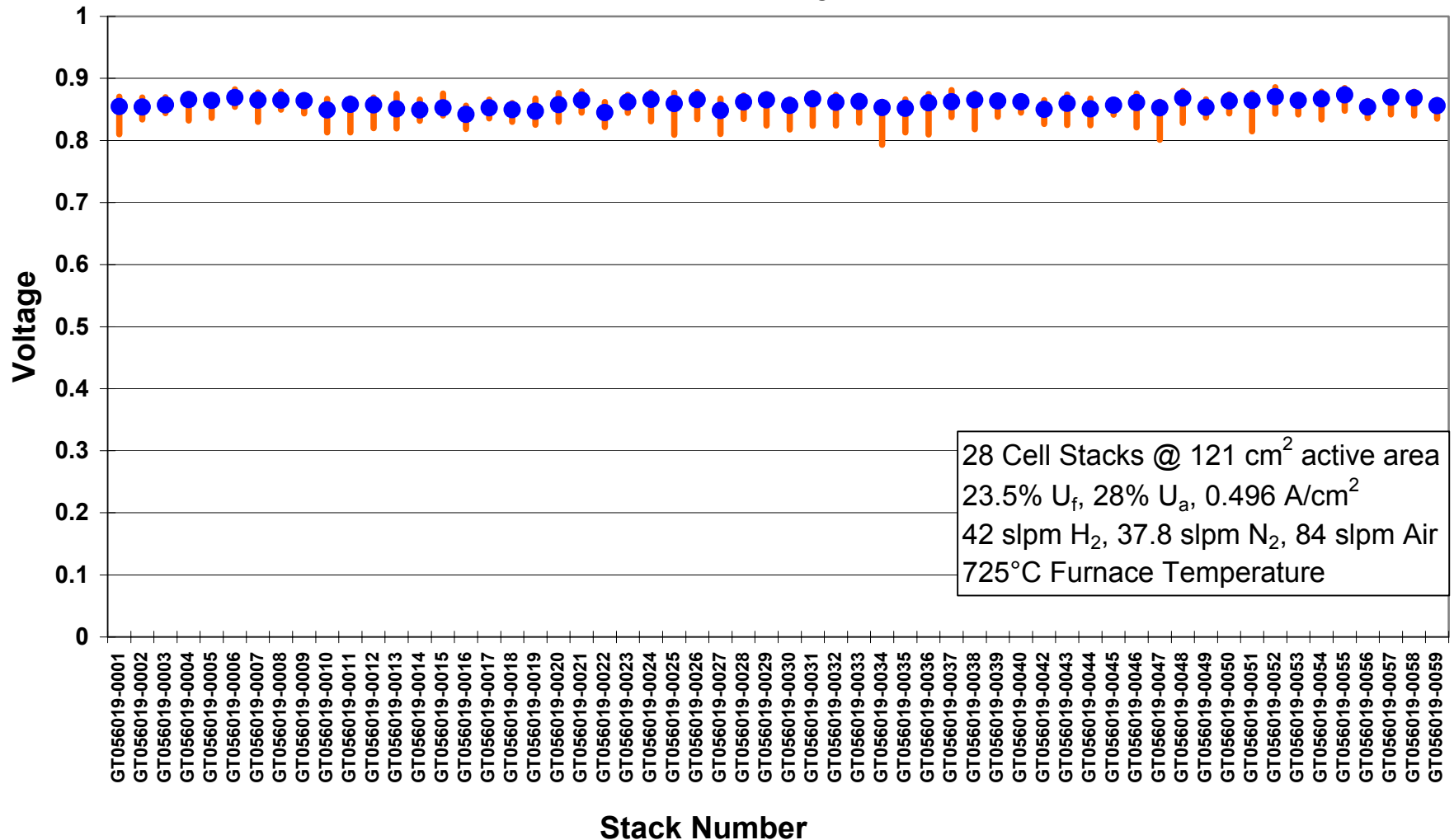
Stack Performance: 28 x 121 cm² active area cells

GT056019-0009, TC1, 28 Cell Stack



Stack Performance: 28 x 121 cm² active area cells

28 Cell Stacks
60A, TC1 and 3 hour hold
Min/Max/Average





System Demonstration Results

3 kW Prototype System (3-1)

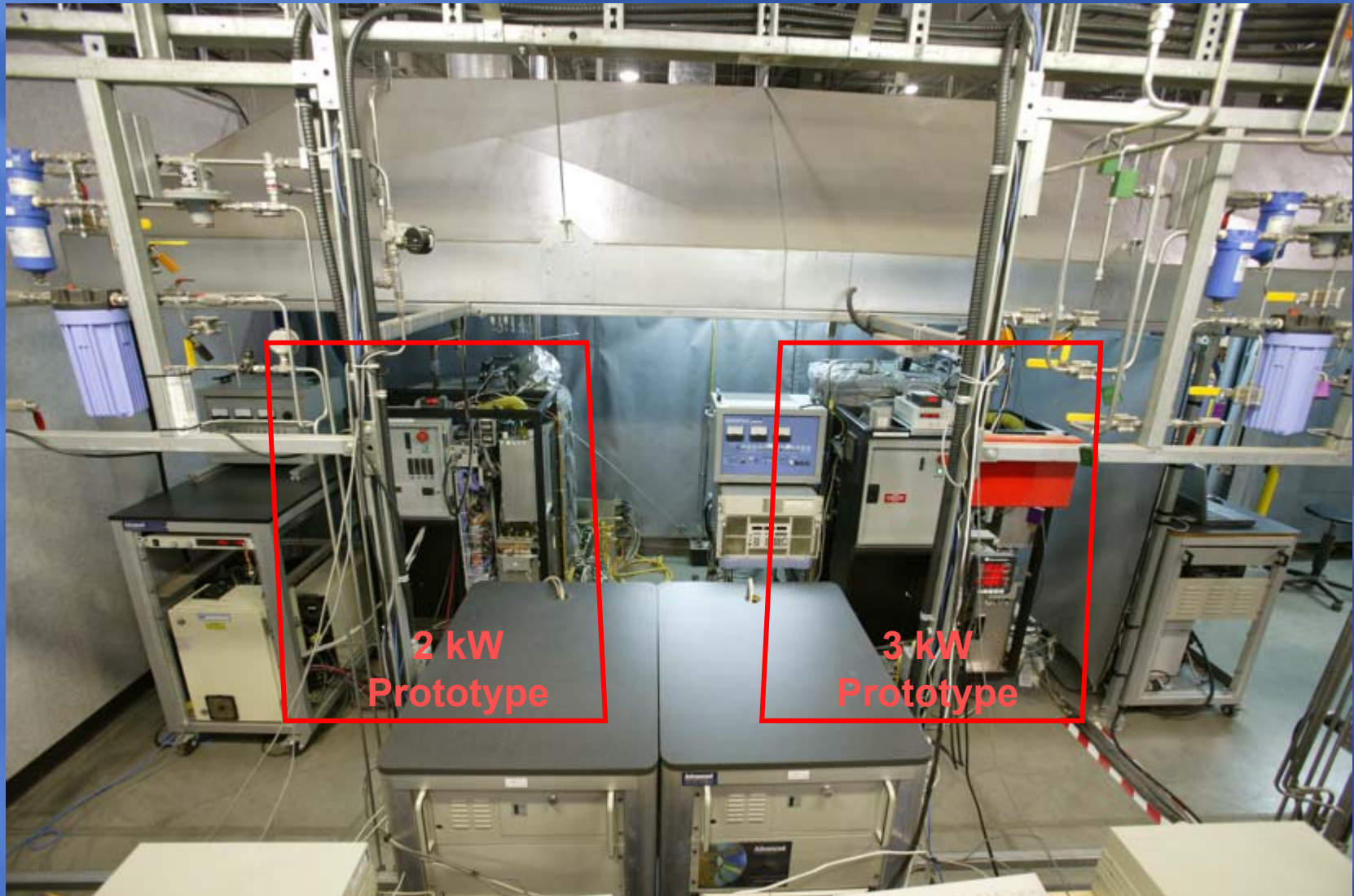


- Thermally integrated power system
- Pipeline natural gas fuel
- Autonomous control
- Grid connected (parallel)
- Designed towards applicable codes and standards compliance
- Builds on the experience gained from >40,000 h of accumulated operation of previous prototypes

System Testing



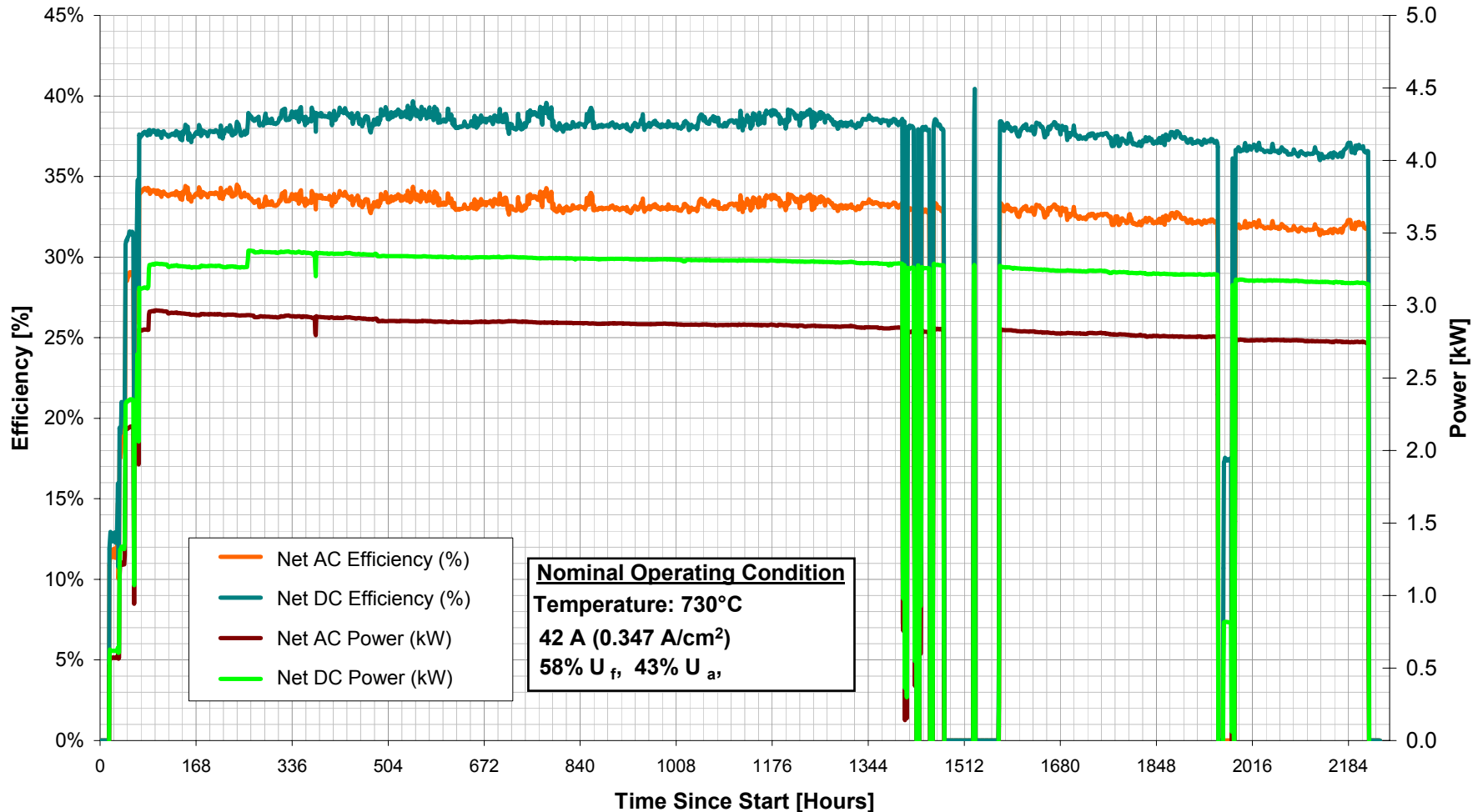
System Testing



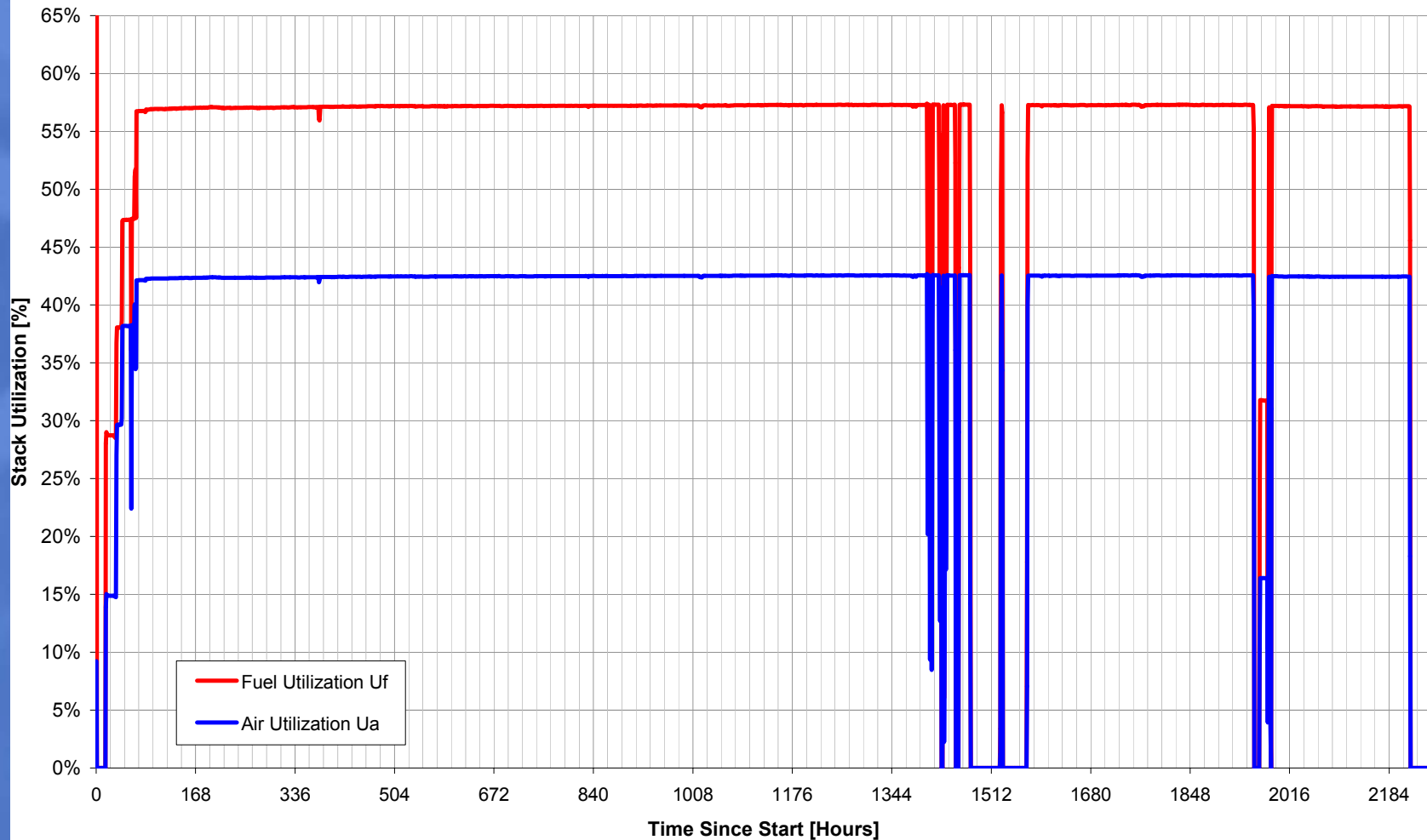
3-1 System Test Plan

- 1,000 h steady-state operation at constant current
- 5 'zero net' electrical transients
(system supplies parasitic power requirements only, no net export of power to grid)
- 2 'zero gross' electrical transients
(also known as 'open circuit, hot hold')
- 1 thermal cycle to 600°C
- 2 thermal cycles to <50°C
- 500 h steady state operation at constant current
- Peak power demonstration

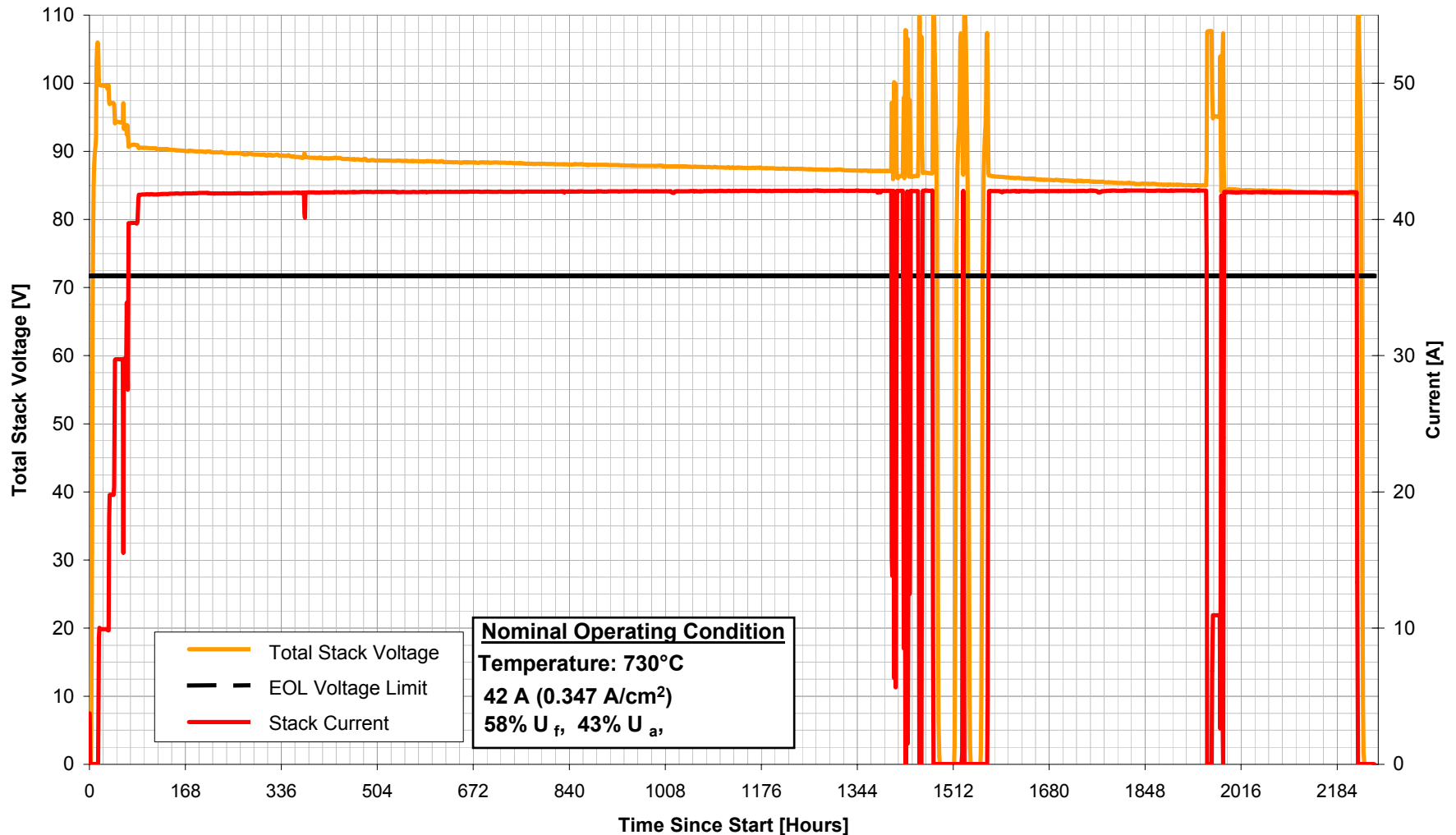
Efficiency and Power Output 3-1 System



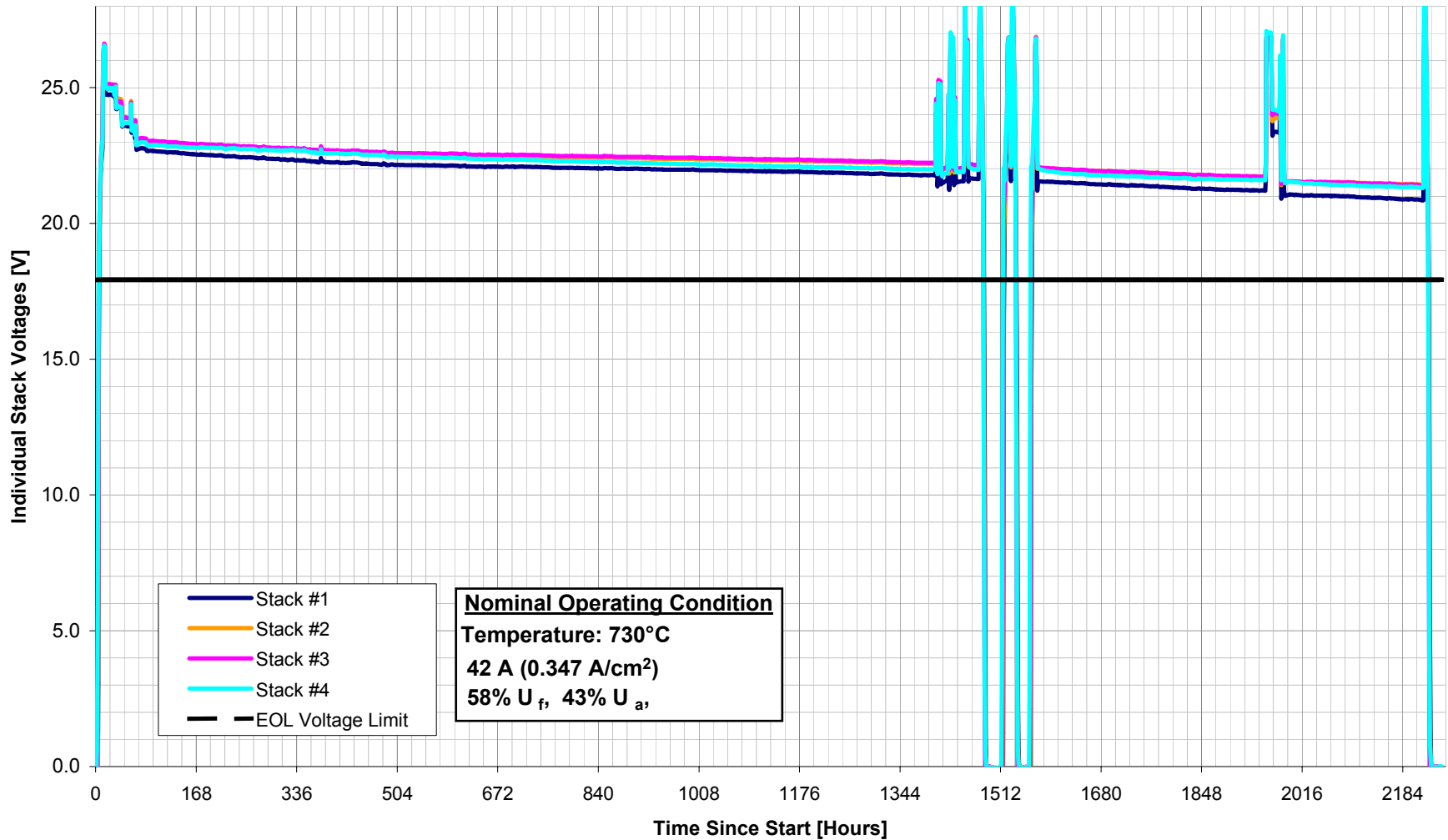
Stack Fuel and Air Utilizations 3-1 System



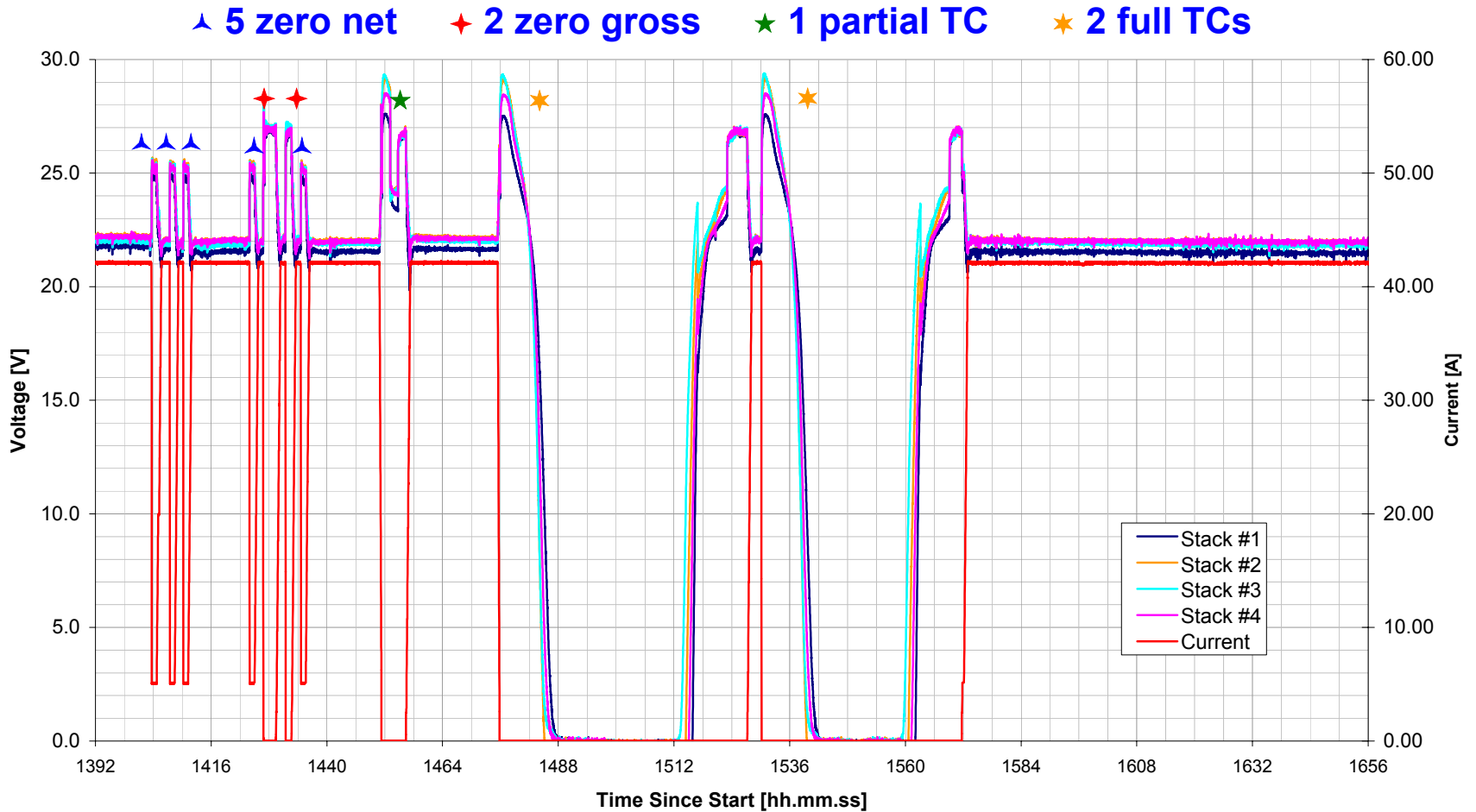
Total Stack Voltage and Current 3-1 System



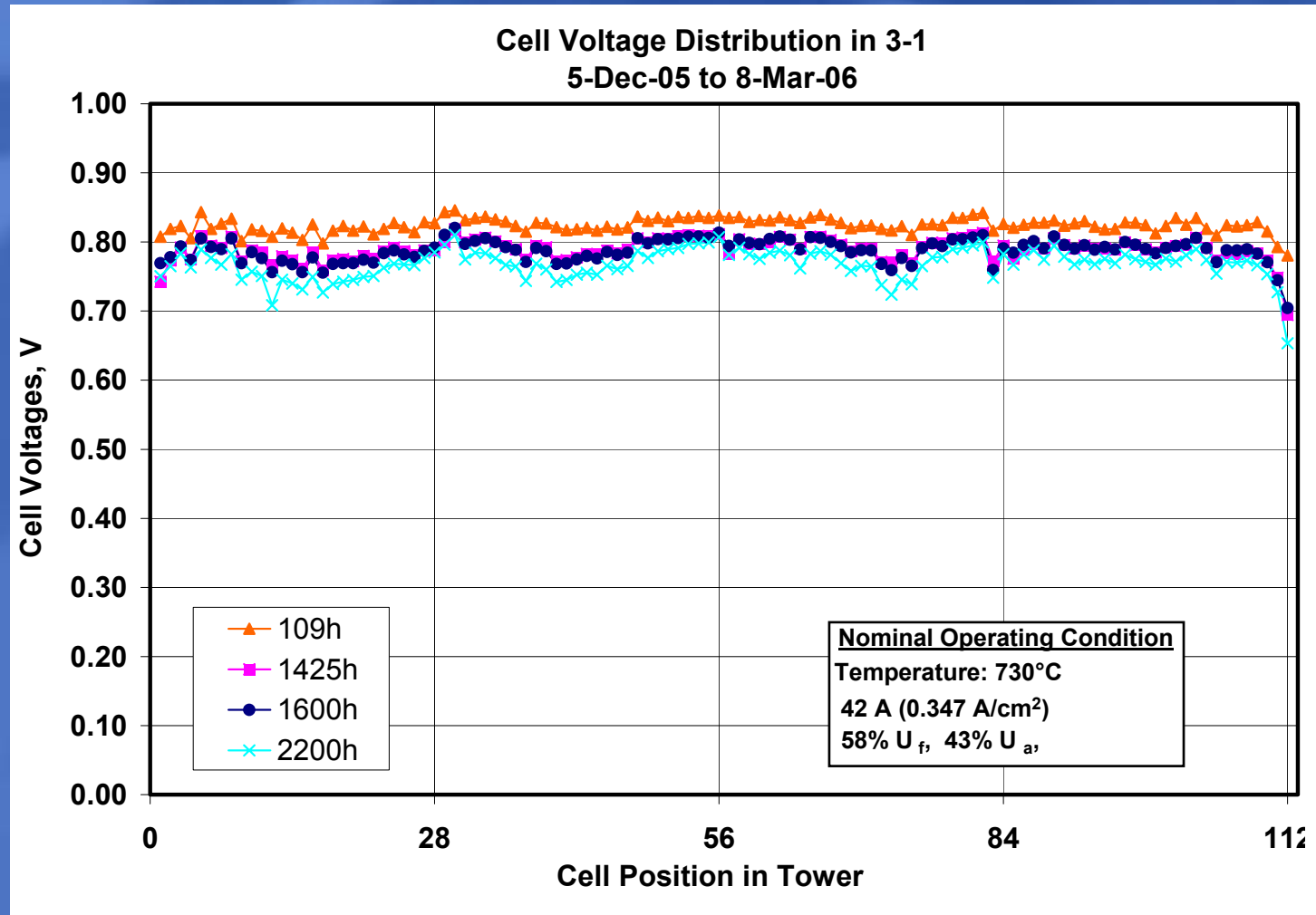
Stack Module Voltages 3-1 System



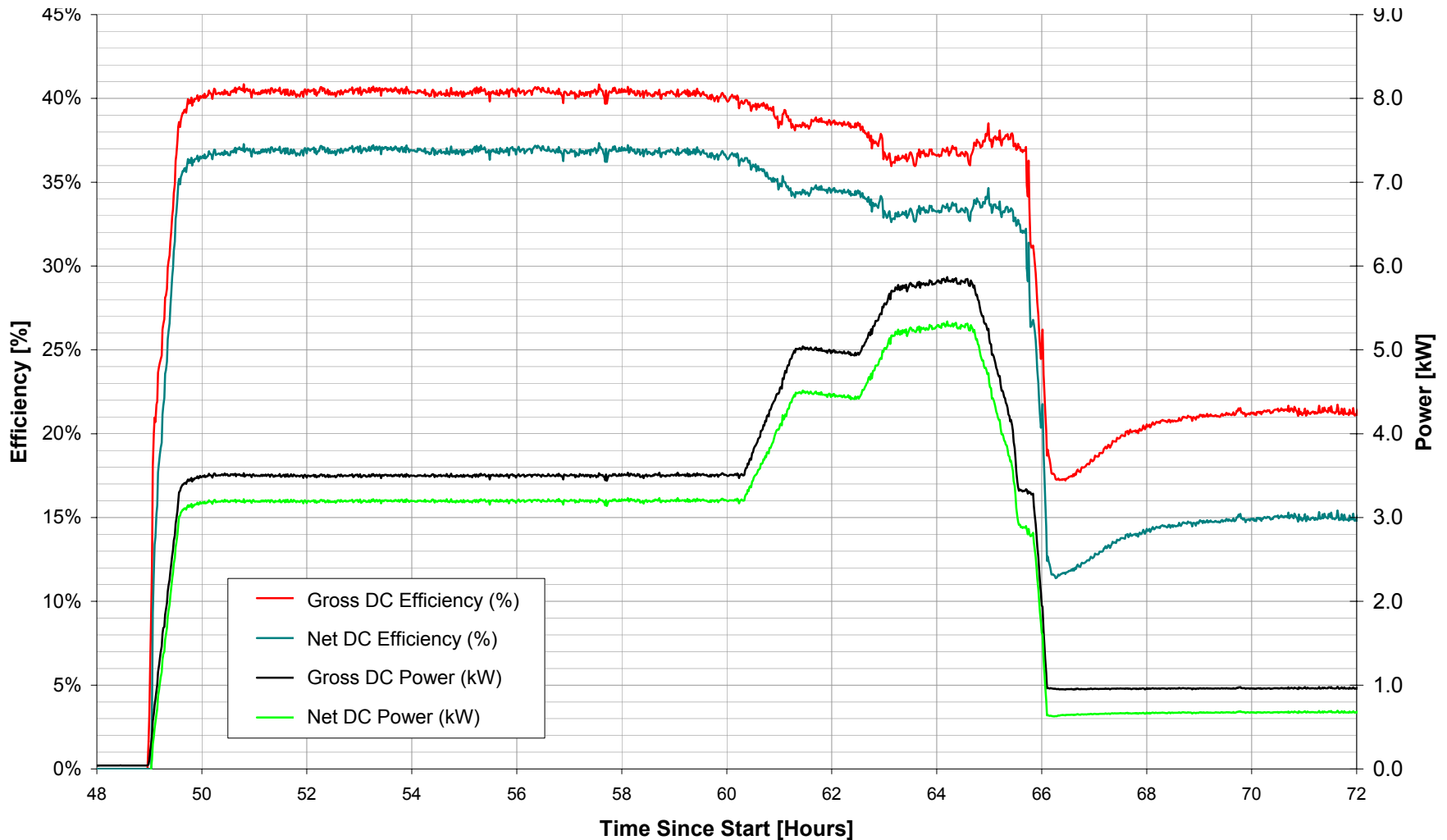
Transient Testing 3-1 System



Voltage Distribution in 112 Cell Tower Operating in 3 kW System



Peak Power Testing 3-1 System



3-1 kW System Test Summary

	NOC BOL	NOC EOT	Peak Power
Fuel Utilization	58%	58%	60%
Air Utilization	43%	43%	46%
Stack Current	42 A	42 A	80 A
Net DC Electrical Power	3.39 kW	3.13 kW	5.26 kW
Net AC Electrical Power	2.96 kW	2.74 kW	-
Net DC Electrical Efficiency	38.7%	36.4%	33.3%
Net AC Electrical Efficiency	33.9%	31.8%	-
Availability	98.6%		-

Notes: Hourly averaged data

Efficiencies based on LHV Calgary pipeline natural gas



Conclusions

- **The largest challenge with respect to the commercialization of SOFC technology is the simultaneous convergence of Performance, Cost and Function.**
- **Materials research, stack engineering and system development efforts at Versa Power Systems are aligned to these objectives.**