

The Status of SOFC Development at Versa Power Systems

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**Ninth International Symposium on
Solid Oxide Fuel Cells (SOFC-IX)**

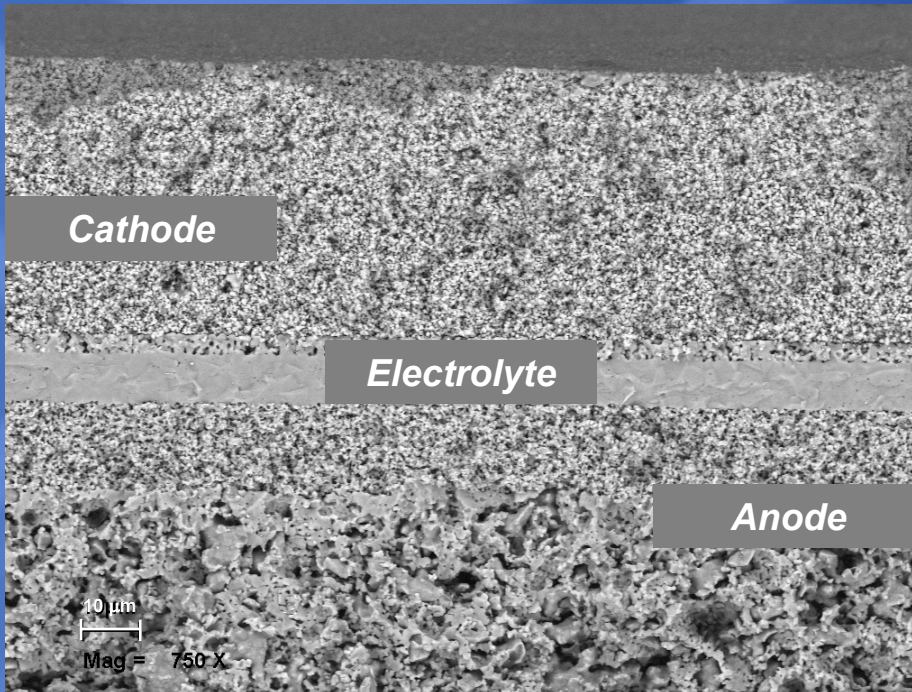
16 May 2005

Quebec City, Canada



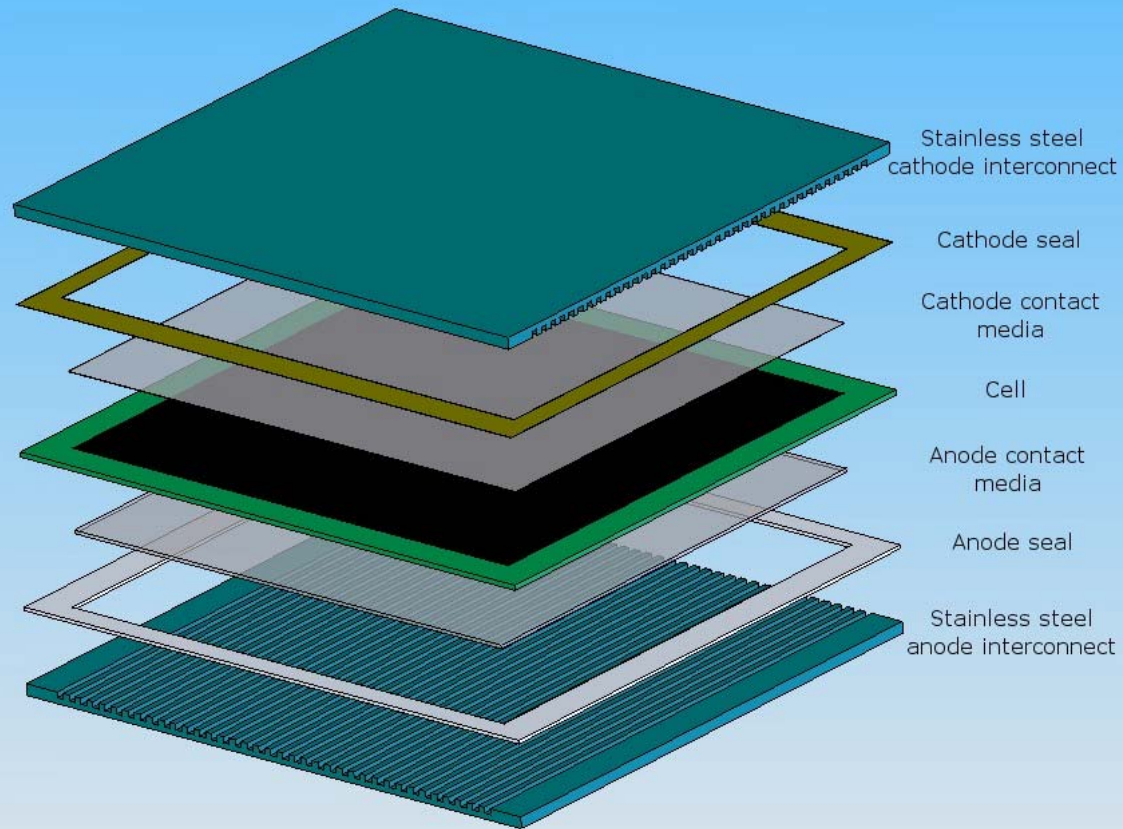
Cell Development

Cell Development



- **Anode** – nickel-zirconia cermet, ~ 1 mm thick
- **Electrolyte** – yttria-stabilized zirconia (YSZ), ~ $10\ \mu\text{m}$ thick
- **Cathode** – conducting ceramic, ~ $50\ \mu\text{m}$ thick

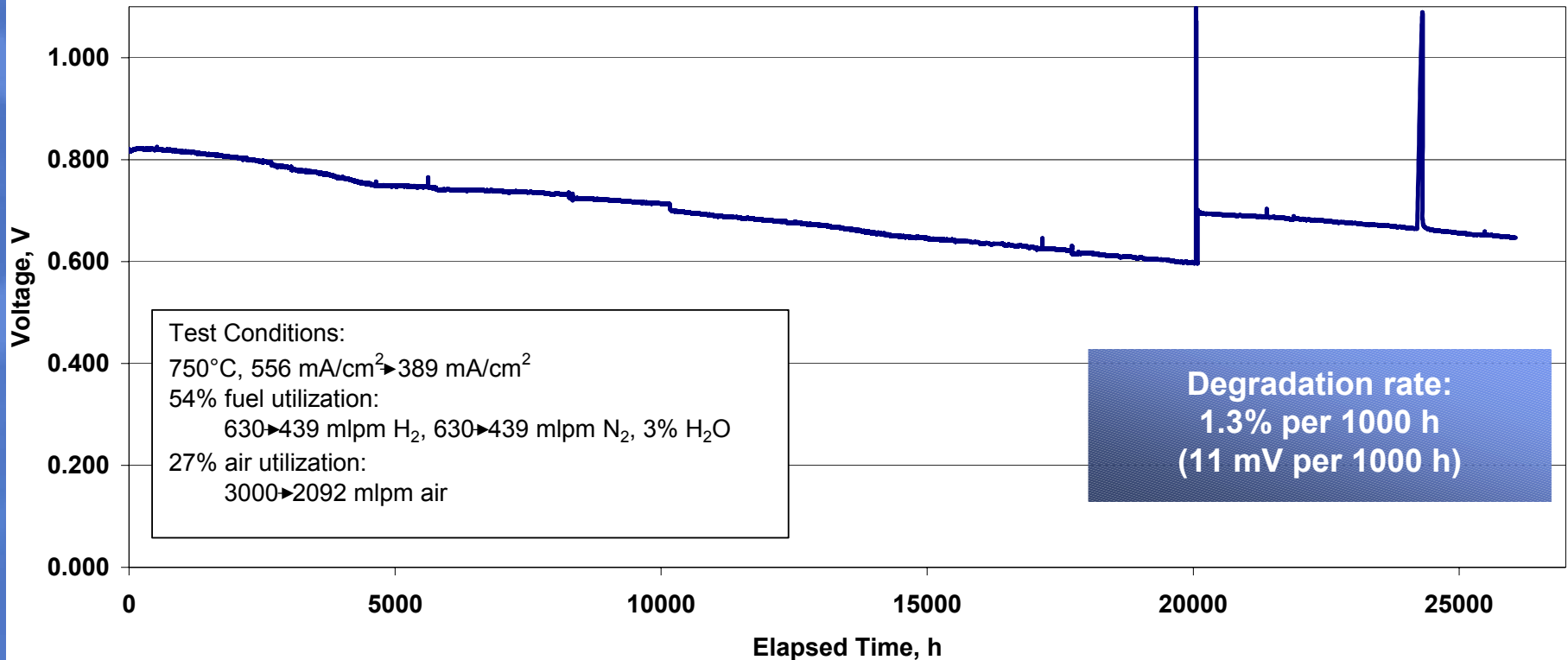
Stack Repeat Unit ("Single Cell") Testing



Single Cell Test

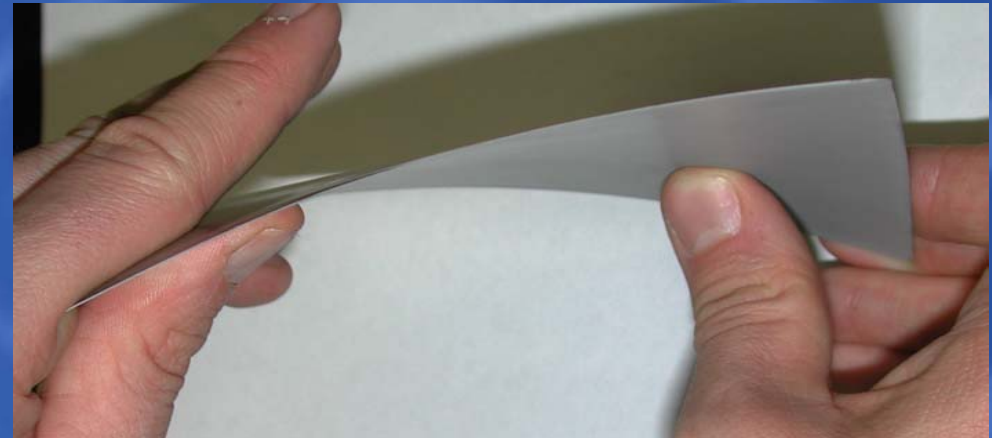
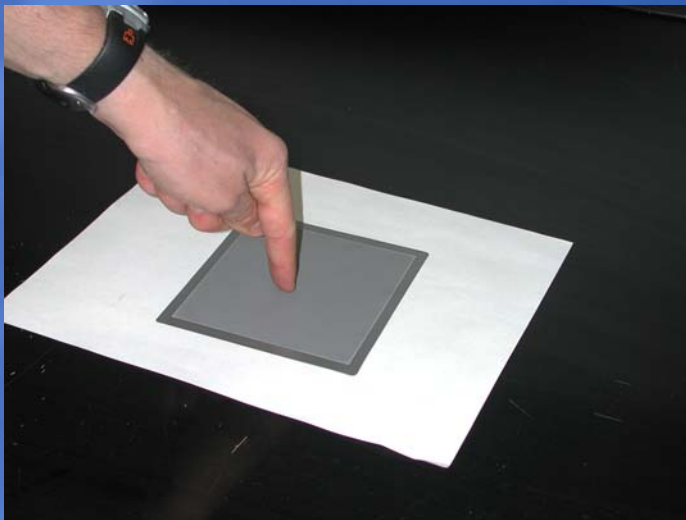
Trend Data

Test #10545; (Long Term Test: TSC1, 10 x 10 cm²)
Test Stand #6, January 9, 2002 - January 10, 2005



Cost Reduction: Thin Cell Development

Cell Thickness	Material Cost Reduction
1 mm	--
0.6 mm	29%
0.3 mm	51%

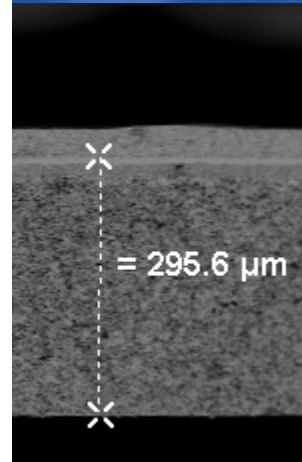
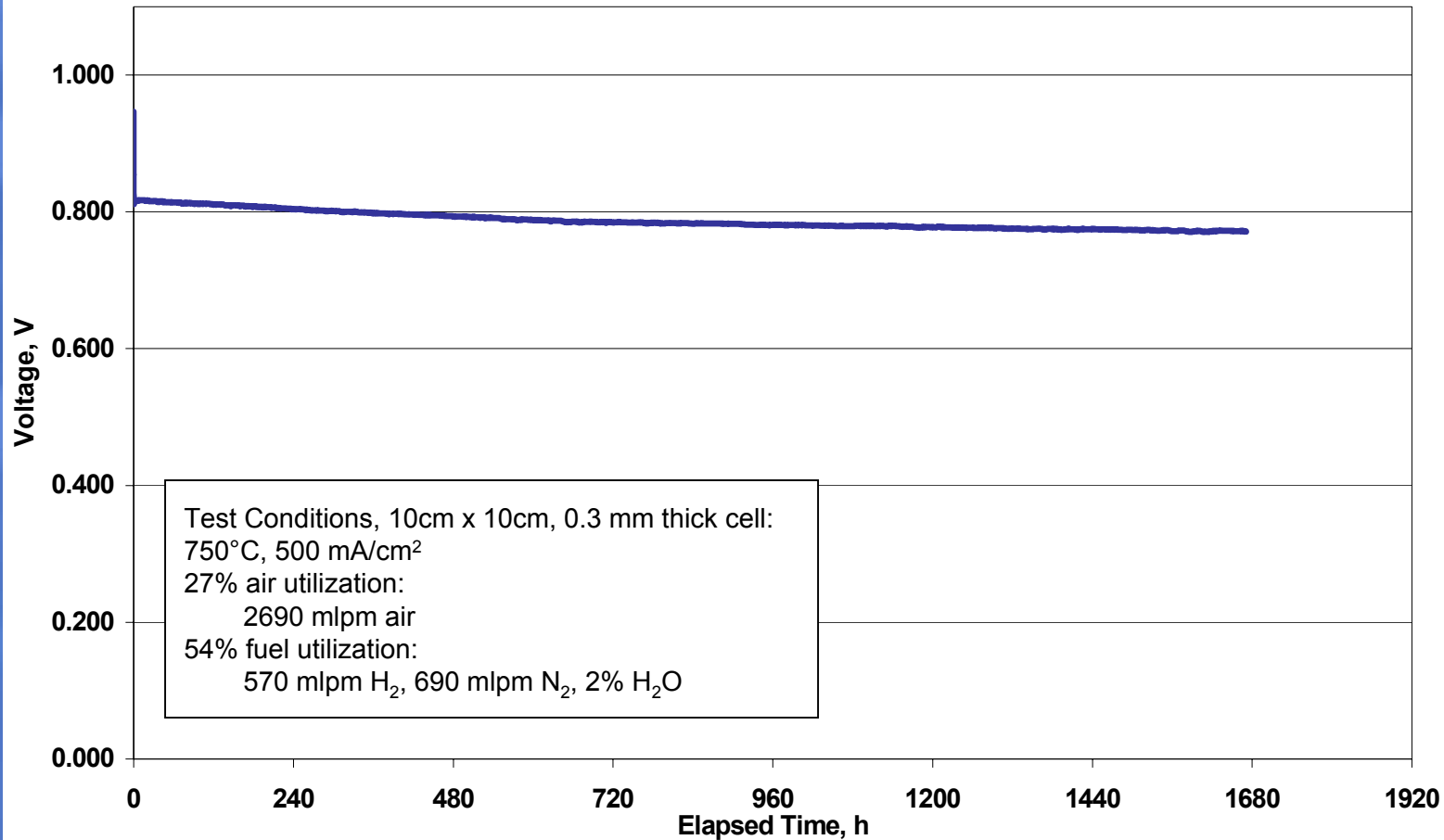


**Reduced cost, increased
power density per kg**

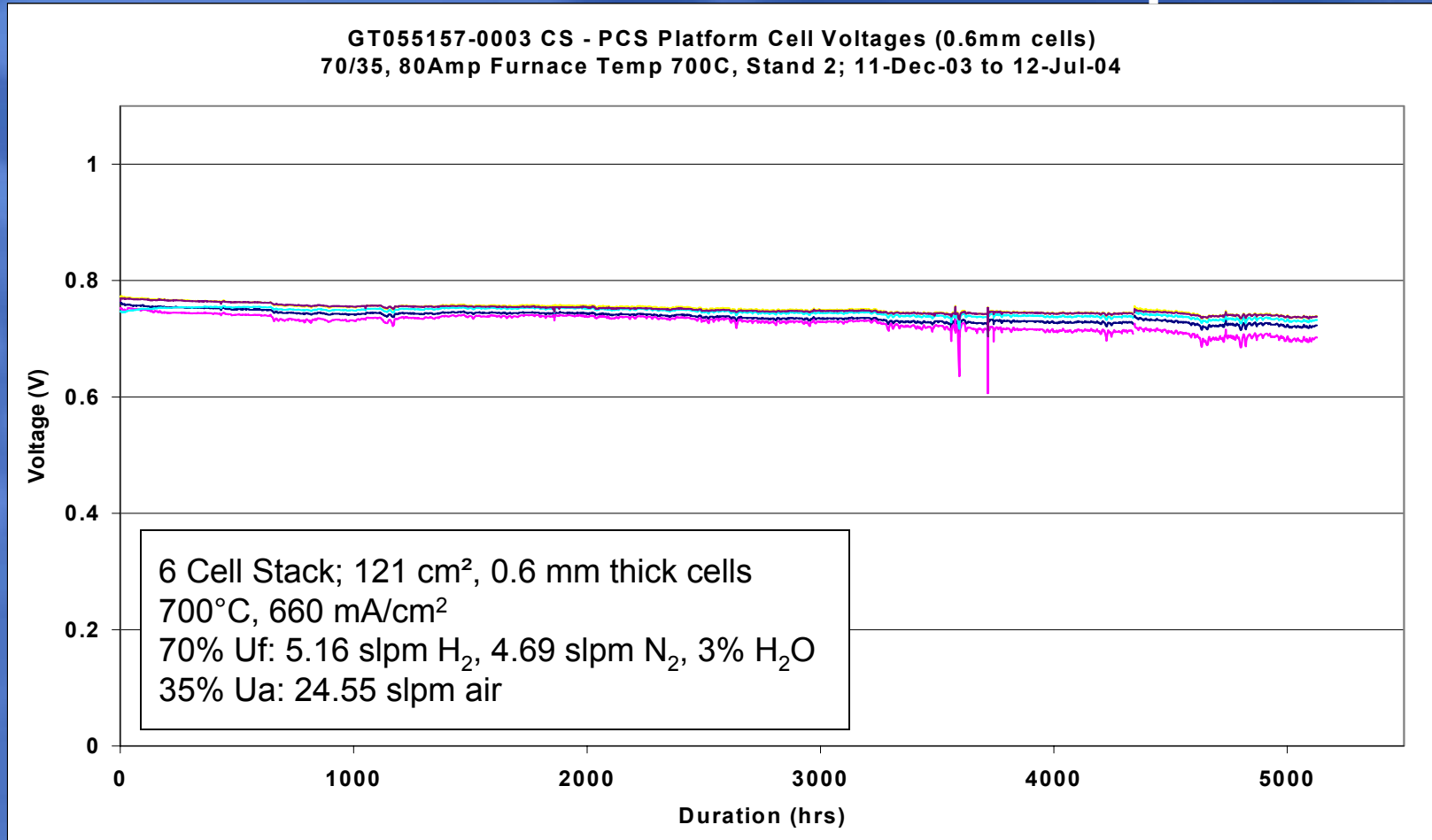
Cost Reduction: Thin Cell Development

Degradation Curve

Glob 101292; (Wafer Thin Cell-2)
Oven #8, (March 29, 2004 - June 9, 2004)



Cost Reduction: Thin Cell Development



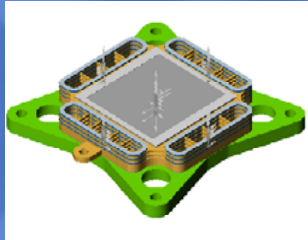
6-cell thin cell stack operated for more than 5,000 hours at 0.49 W/cm² (80 Amps) and 70% fuel utilization.
- Degradation rate 0.74% per 1000 hours (<6 mV per 1,000 hours per cell) -



Stack Development

Stack Development Strategy

Component
Development



Cell

Seal

Interconnect

Contacts

Current Collection

Flow Management

Thermal Management

Manufacturability

Repeatability

Tolerance

Stack
Engineering

Integration



Current Stack Configuration



Cell Active Area	121 cm ²
Number of Cells	21



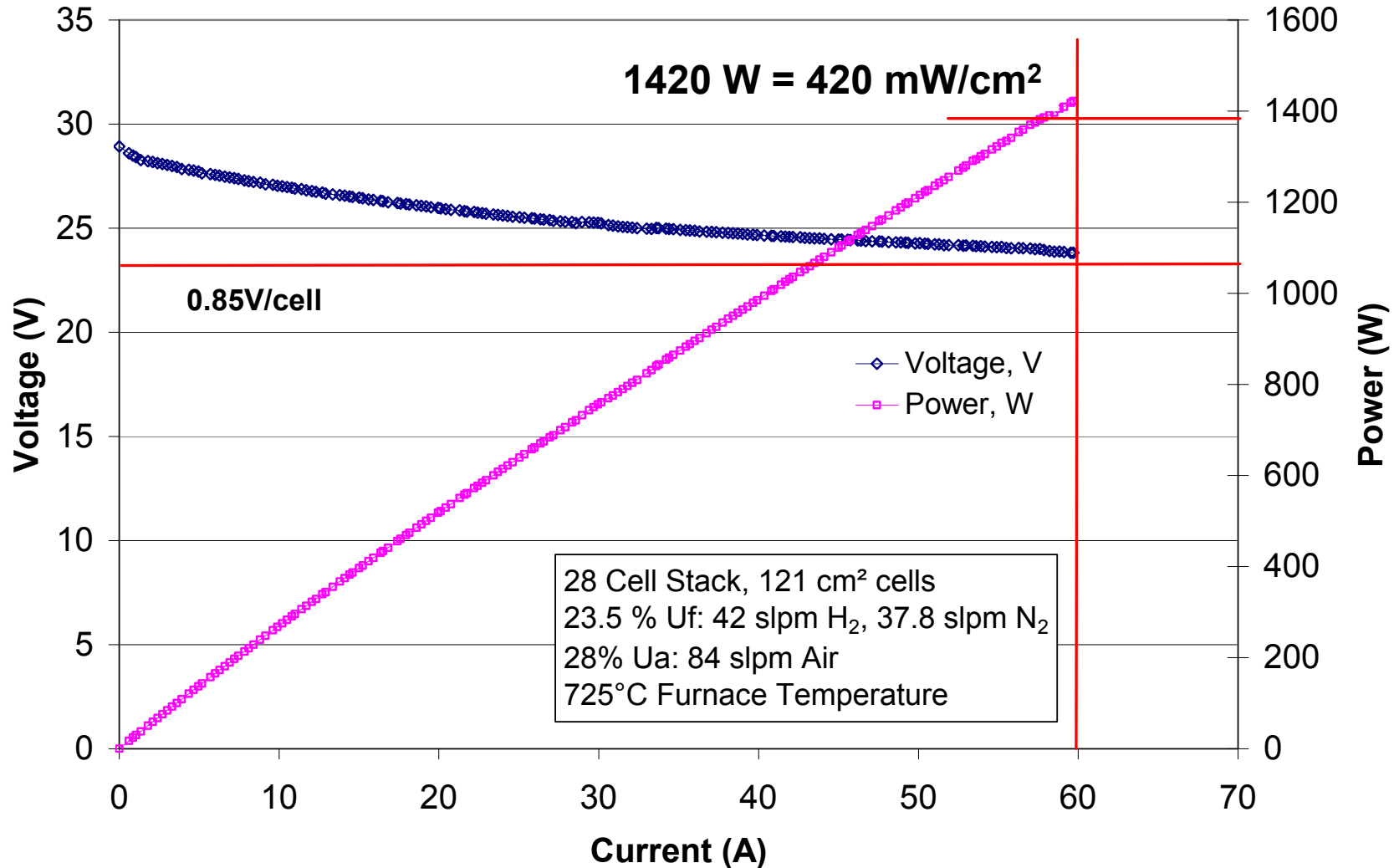
Cell Active Area	121 cm ²
Number of Cells	28



40% Increase in Active Area

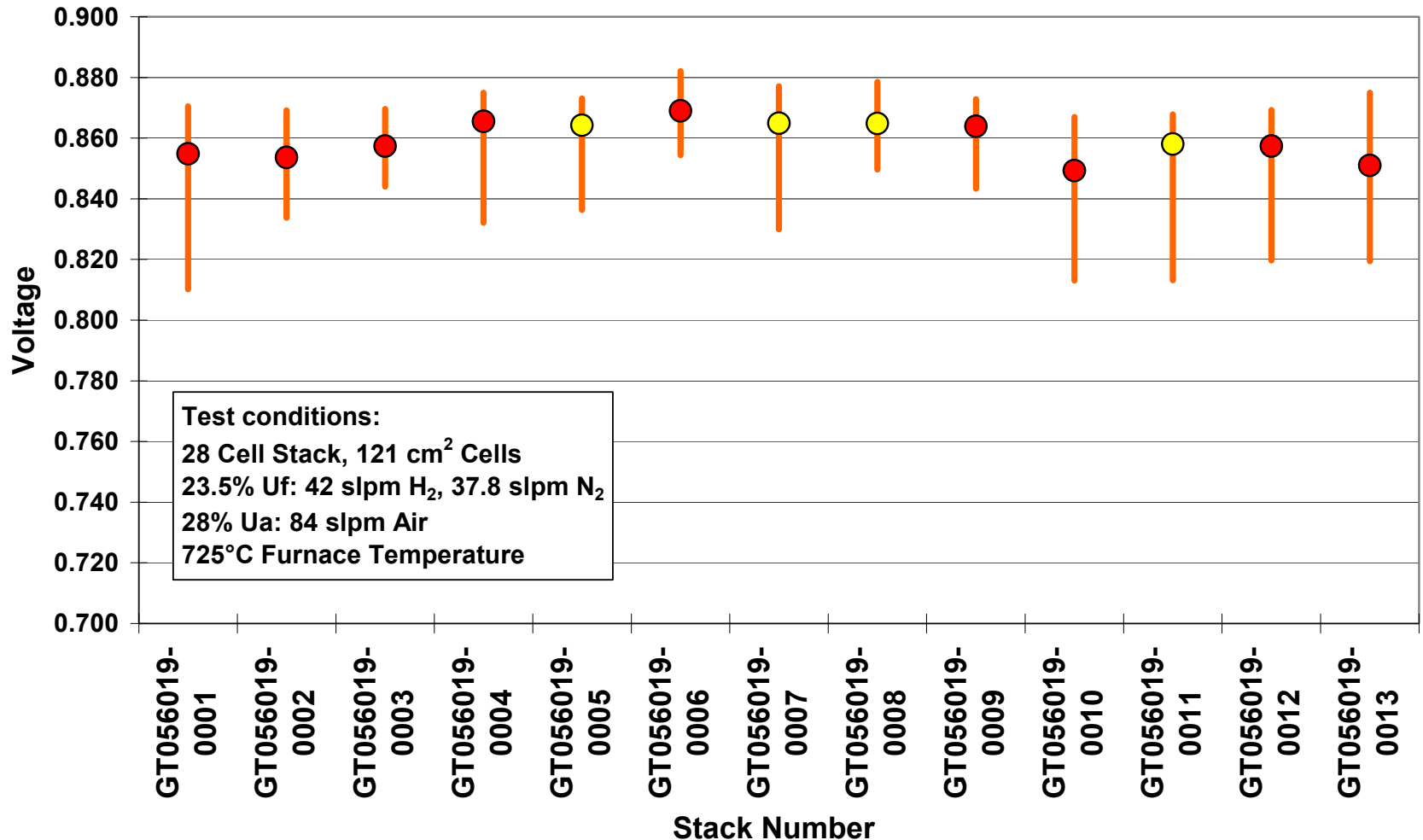
Stack Performance: 28 x 121 cm² active area cells

GT056019-0009 - 28 Cell Stack
12-Mar-05, 24/28/60



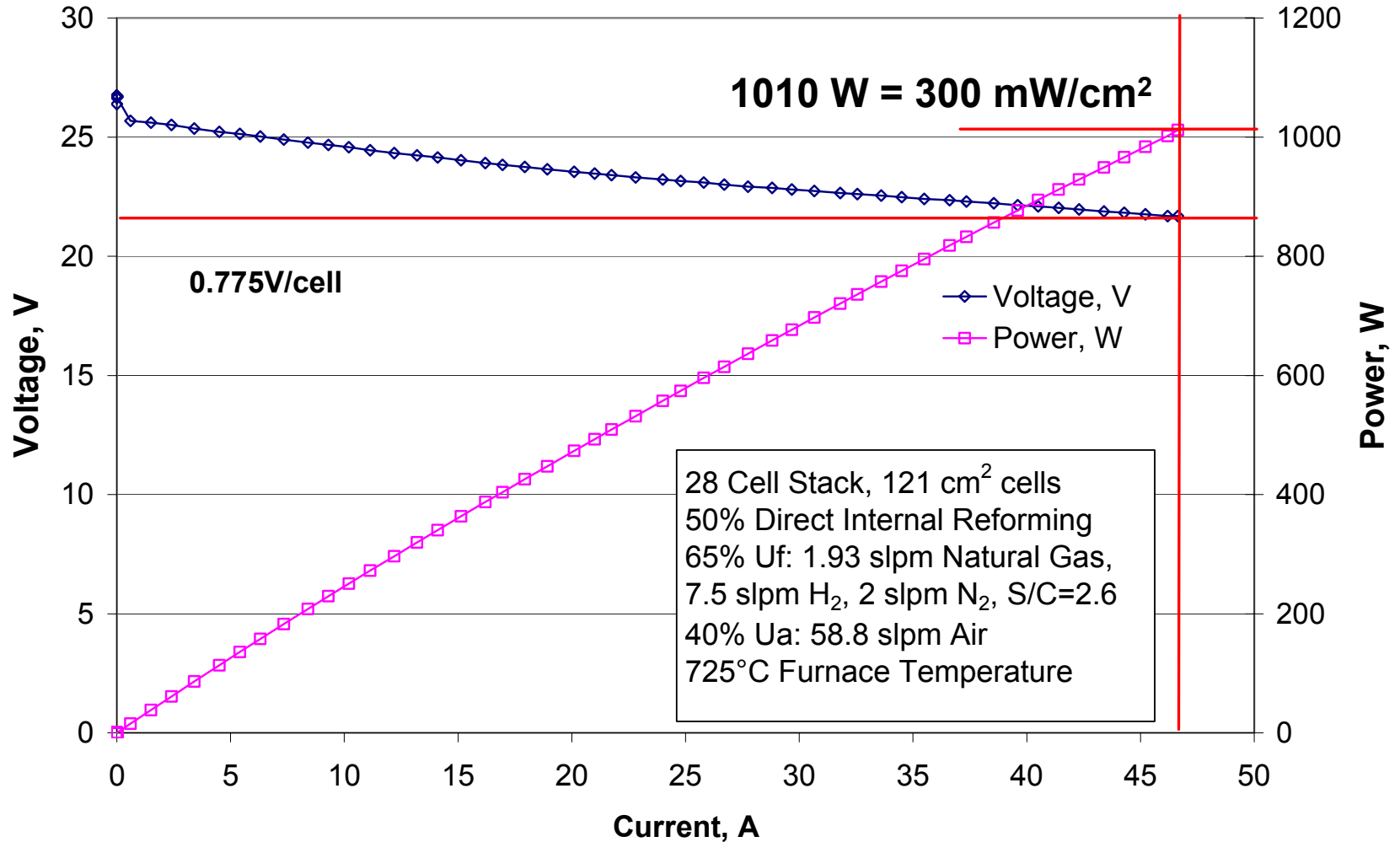
Stack Performance: 28 x 121 cm² active area cells

2-Feb-05 Design Freeze
60 A (full flows) Voltages, after 3 hour hold, TC1
Min/Max/Average, Yellow labels indicate 3-1 system stacks



Stack Performance: 28 x 121 cm² active area cells

GT056019-0009, TC1, 28 Cell Stack
13-Mar-05, 65/40/47/50%





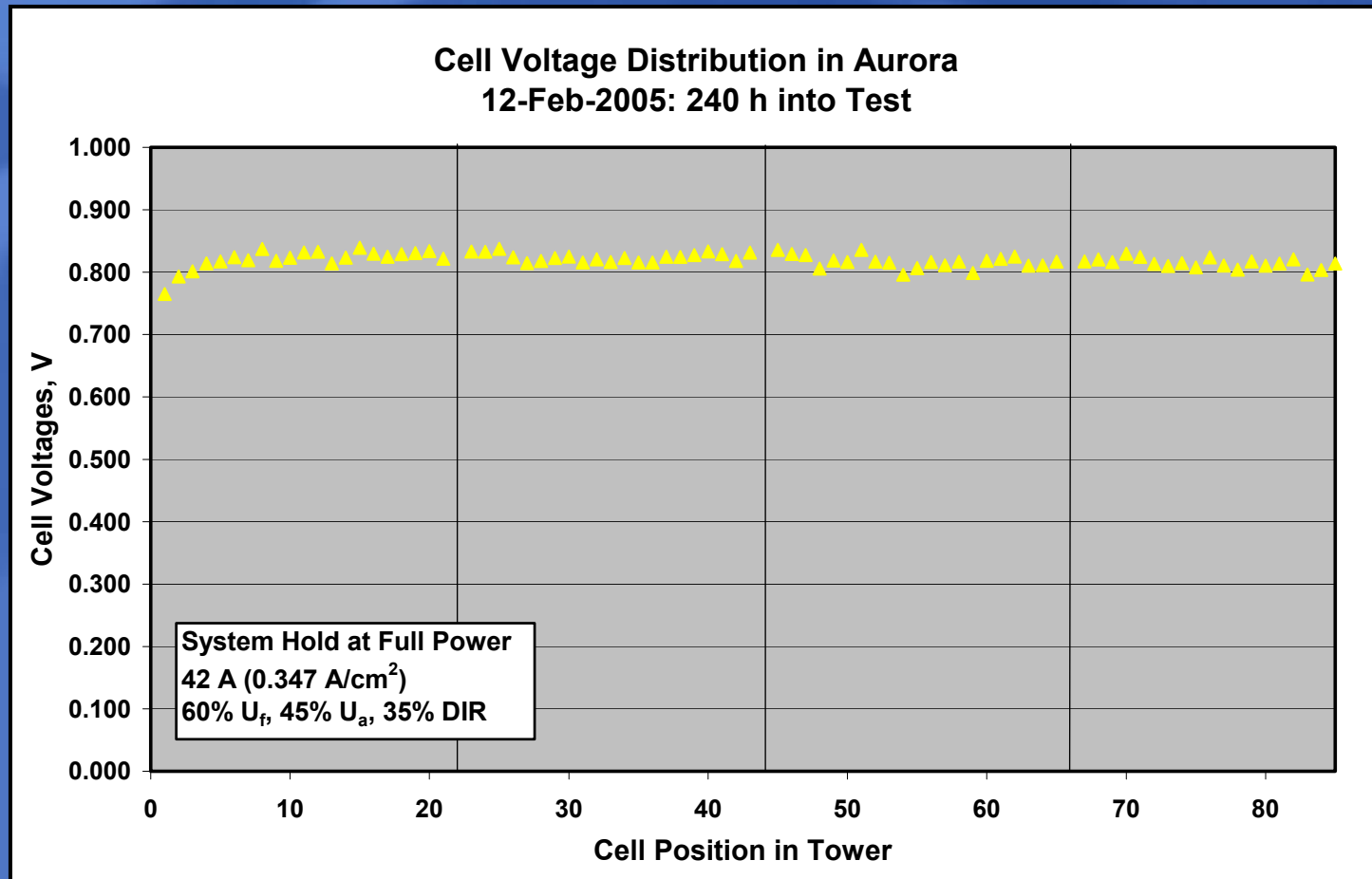
System Development

2 - 3 kW Prototype System

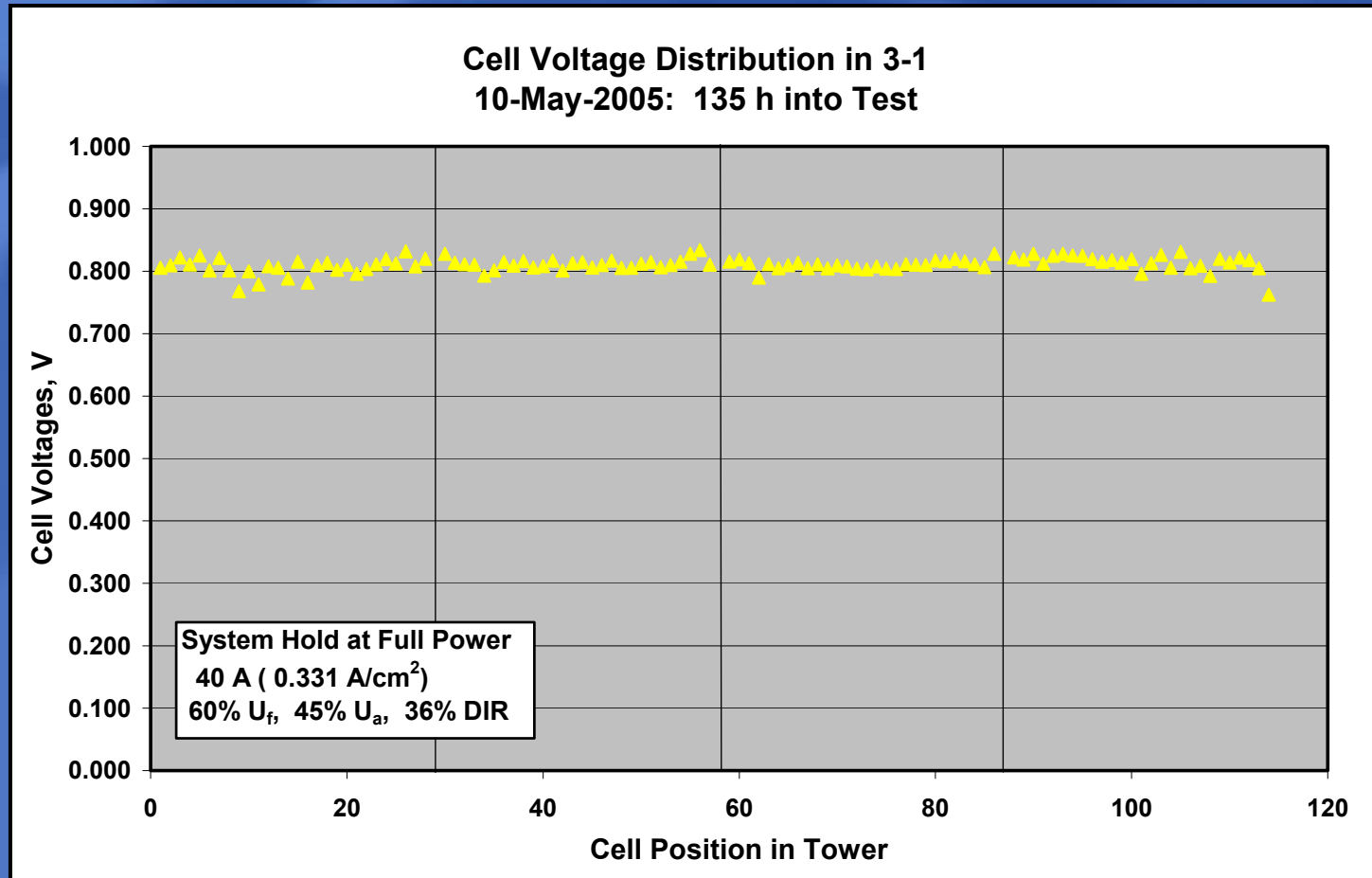


- Thermally integrated power system
- Natural gas fuelled
- Grid parallel
- Designed towards applicable codes and standards compliance

Voltage Distribution in 84 Cell Tower Operating in 2 kW System

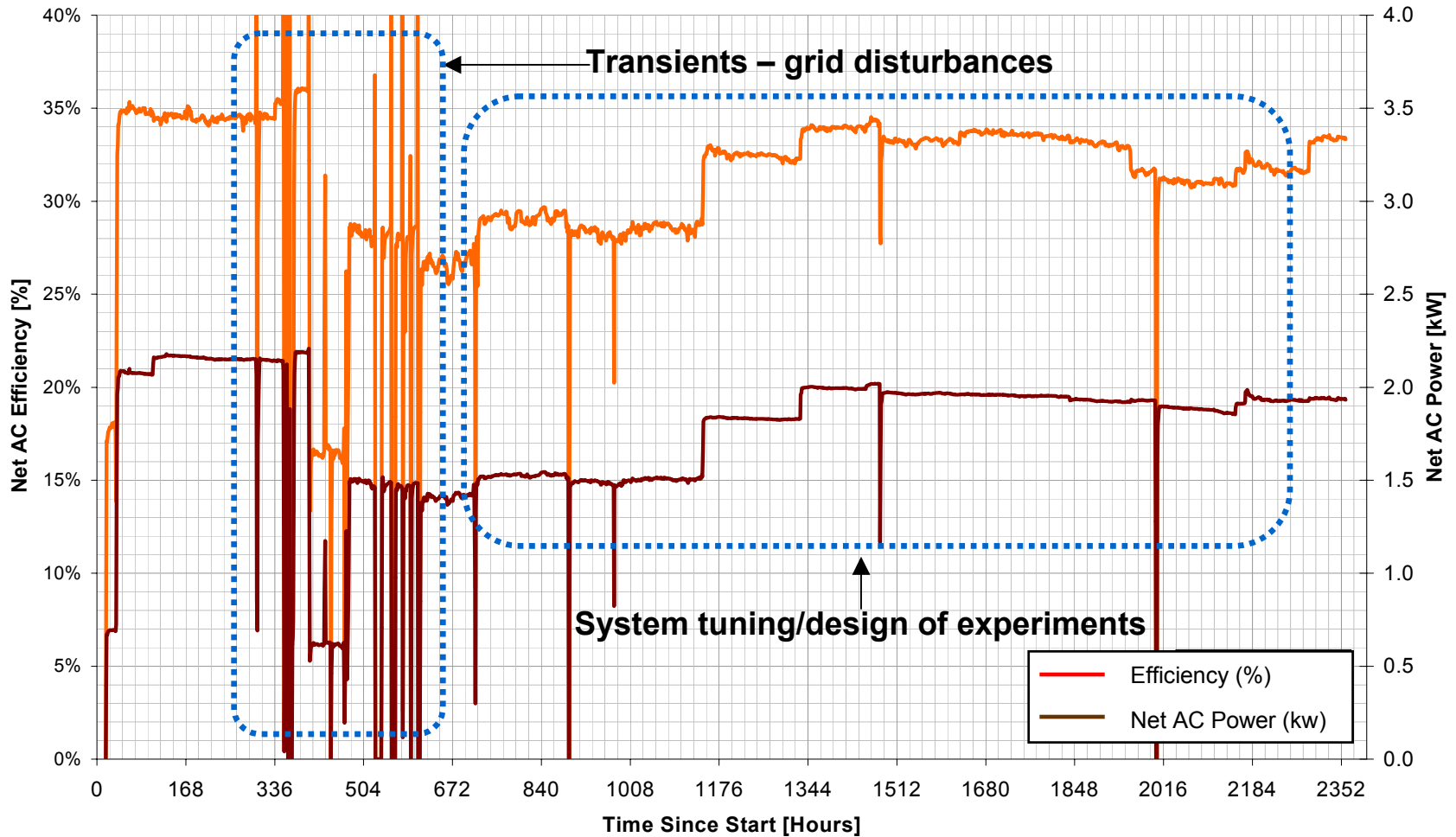


Voltage Distribution in 112 Cell Tower Operating in 3 kW System



Net AC Efficiency and Power Output

System Net AC Efficiency & Net AC Power vs. Time



2 kW Prototype System Run Summary



Peak Net AC Power Output	2.21 kW
Average Net Power Output	1.8 kW
Stack Operating Temperature	732.5°C
Fuel Utilization	60%
Air Utilization	45%
Direct Internal Reforming	25%
Peak Net AC Electrical Efficiency	35.4%
Average Net AC Electrical Efficiency	31%



Conclusions

Cell:

- 26,000 h of continuous operation demonstrated
- Post test analysis results will be used to implement further improvements
- Result from thin cells are quite promising

Stack:

- Stack platform has been successfully upsized
- Very reproducible results have been demonstrated

System

- Stack tower voltages are uniform; a result of proper flow management and stack fabrication consistency
- System tuning will continue in order to refine control algorithms for operability and long stack life