

# **Design and Performance Data For 81 Ah FNC Cells**

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**Rocketdyne / Acme Aerospace**

**FNC**

## **Background**

### **Rocketdyne FNC Activity**

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- **Rocketdyne contracted with Acme Aerospace in early 1994 to develop and test an 81 Ah FNC cell as a lower cost alternative to Ni-H2 cells currently targeted for the International Space Station**
- **Acme designed, developed, tested and initiated LEO cycle testing 8 months from receipt of contract award**
- **Rocketdyne has accumulated 2 years of LEO cycle test data under several accelerated test regimes**
- **This presentation is the first public release of Rocketdyne/Acme 81 Ah FNC cell performance and cycle life data**

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## **Background FNC Technology**

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- **Acme Aerospace started production of FNC cells in 1992 under license from Daug-Hoppecke in West Germany**
- **Several OEM contracts were secured utilizing FNC sealed cells for military and commercial aircraft**
- **Acme slightly modified several 7 Ah aircraft quality cells and began testing at JPL in 1992. These cells achieved 9500 LEO cycles at 40% DOD at 20 ° C**
- **Limited design changes were made in '93-'94 and were implemented in several battery packs subsequently put on LEO tests in '94-'95 both at Acme and at customer's laboratories.**
- **The Rocketdyne test is the most extensive accelerated LEO testing on FNC cells to date**

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## **FNC Cell Design Features**

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<b>Positive Plaque</b>	<b>Nickel plated polyolefin fibers</b>
<b>Positive Impregnation</b>	<b>Mechanical loading @ room temperature, neutral pH, no Nitrates</b>
<b>Negative Plaque</b>	<b>Nickel plated polyolefin fibers</b>
<b>Negative Impregnation</b>	<b>Mechanical loading @ room temperature, neutral pH, and no Nitrates</b>
<b>Separator</b>	<b>Polypropylene permanently wettable Pore size less than 5 micron</b>
<b>Electrolyte</b>	<b>30% KOH</b>
<b>Terminals</b>	<b>Nickel</b>
<b>Terminal Seals</b>	<b>Ziegler Crimp Seal</b>
<b>Case</b>	<b>Welded stainless steel, hermetically sealed</b>

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## **X81 Design Parameters**

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<b>Theoretical Positive Capacity</b>	<b>96 Ah +/- 3</b>
<b>Theoretical Negative Capacity</b>	<b>275 Ah +/- 6</b>
<b>Theoretical Neg/Pos Ratio</b>	<b>2.85 +/- 0.15</b>
<b>Active Neg/Pos Ratio</b>	<b>2.1 +/- 0.1</b>
<b>Positive Electrode Loading</b>	<b>1.5 g/cc void</b>
<b>Separator Thickness</b>	<b>12 mil</b>
<b>Electrolyte Volume</b>	<b>4.1 +/- 0.1 ml/design Ah</b>
<b>Weight</b>	<b>2860 g +/- 30 g</b>
<b>Mid-Design Energy Density</b>	<b>40 Wh/kg</b>
<b>Internal Impedance @ 1 sec, 24° C</b>	<b>0.46 mohm</b>

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# ATP DATA

<u>Cell Number</u>	<u>Ref. Capacity C/2 Ah</u>	<u>Impeadance 1 Sec mohm</u>	<u>LEO Profile</u>
* 6	81.0	0.54	27°C Accelerated
7	85.2	0.52	"
8	84.9	0.54	"
9	85.2	0.54	-10°C Accelerated
10	84.3	0.51	"
11	84.6	0.51	"
12	85.2	0.54	10°C @ 60% DOD
13	84.7	0.54	"
14	85.2	0.54	"
* 22	89.9		10°C Accelerated
15	84.5	0.53	"
16	85.8	0.54	"
17	84.5	0.52	"
18	84.2	0.51	10°C Nominal
19	84.9	0.53	"
20	84.1	0.54	"
* 1	90.5	0.58	"
* 2	91.0	0.52	"
<b>Average all:</b>	86 +/- 5	0.54 +/- 0.04	
<b>* Avg (excluding 1,2,6,22)</b>	85 +/- 1	0.53 +/- 0.02	

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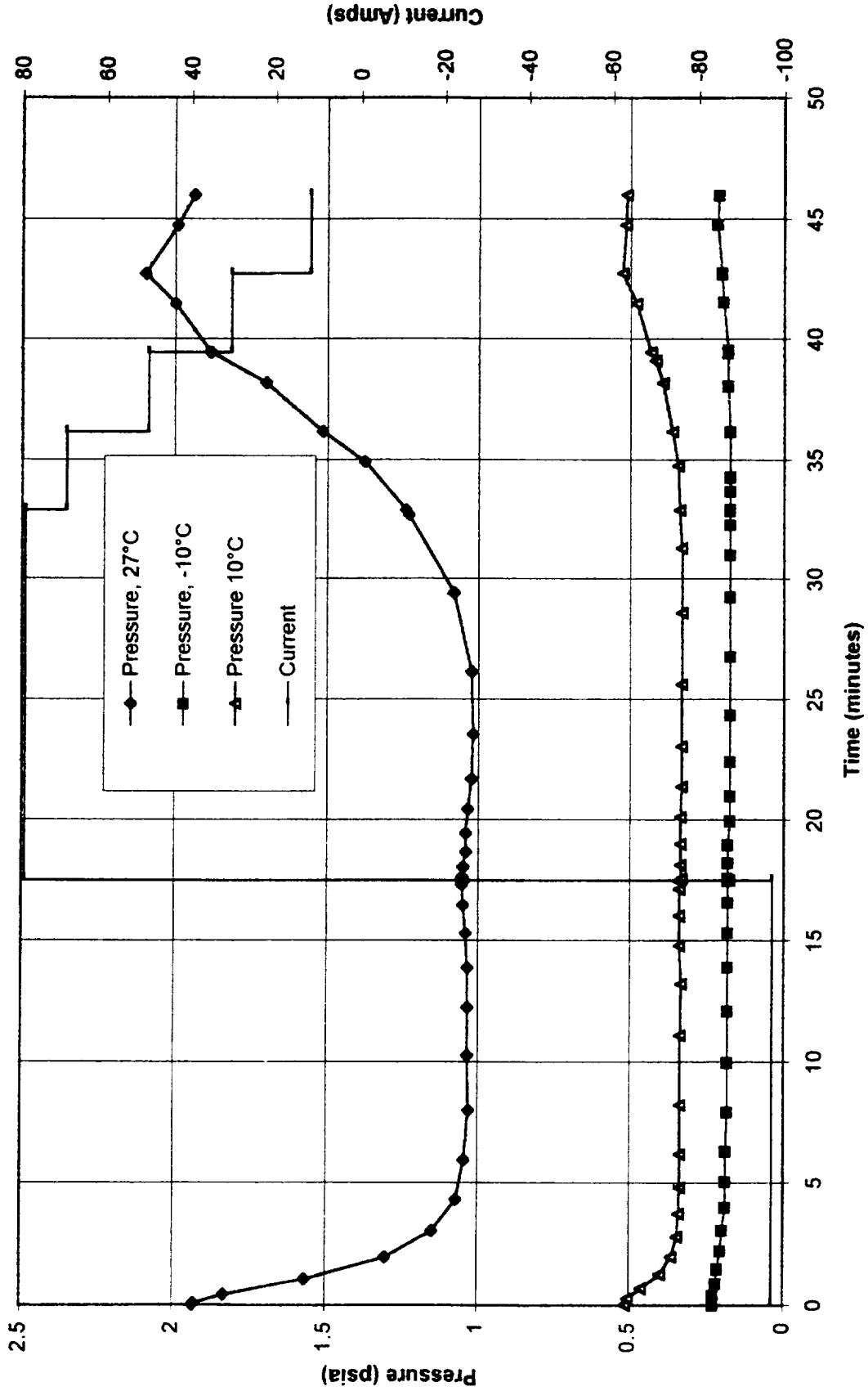
## Test Matrix

<u>Pack Number</u>	<u>Number of Cells</u>	<u>Test Temp</u>	<u>DOD</u>	<u>Disch. Rate</u>	<u>Cycles/Day</u>	<u>Number of Cycles</u>
1	3	27° C	35%	97 Amps	30	9,500
2	3	-10° C	35%	97 Amps	30	13,800
3	4	10° C	35%	97 Amps	30	15,800
4	5	10° C	35%	49 Amps	16	7,900
5	3	10° C	60%	83 Amps	16	7,780

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### 35% DoD Accelerated LEO Current and Internal Pressure

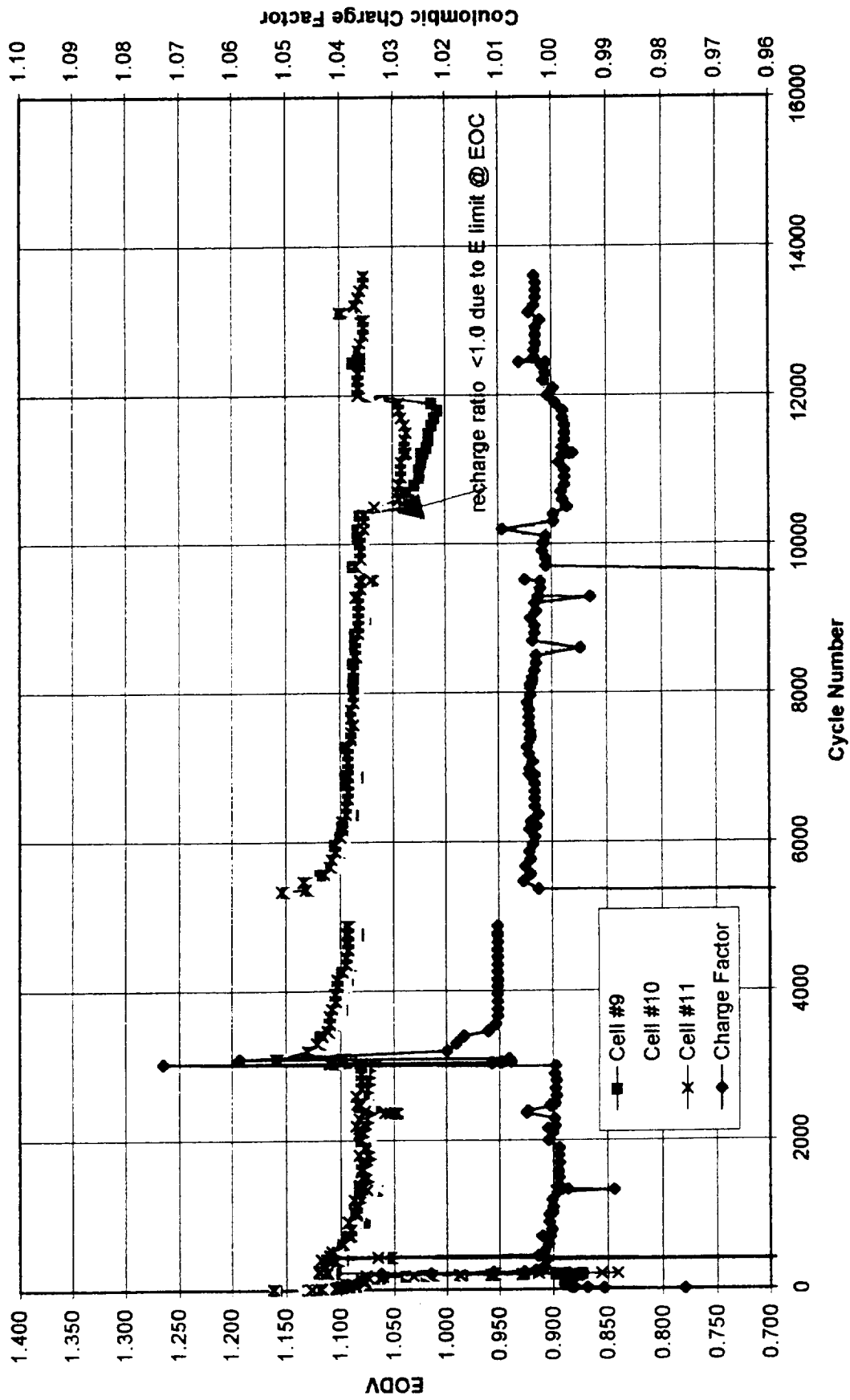


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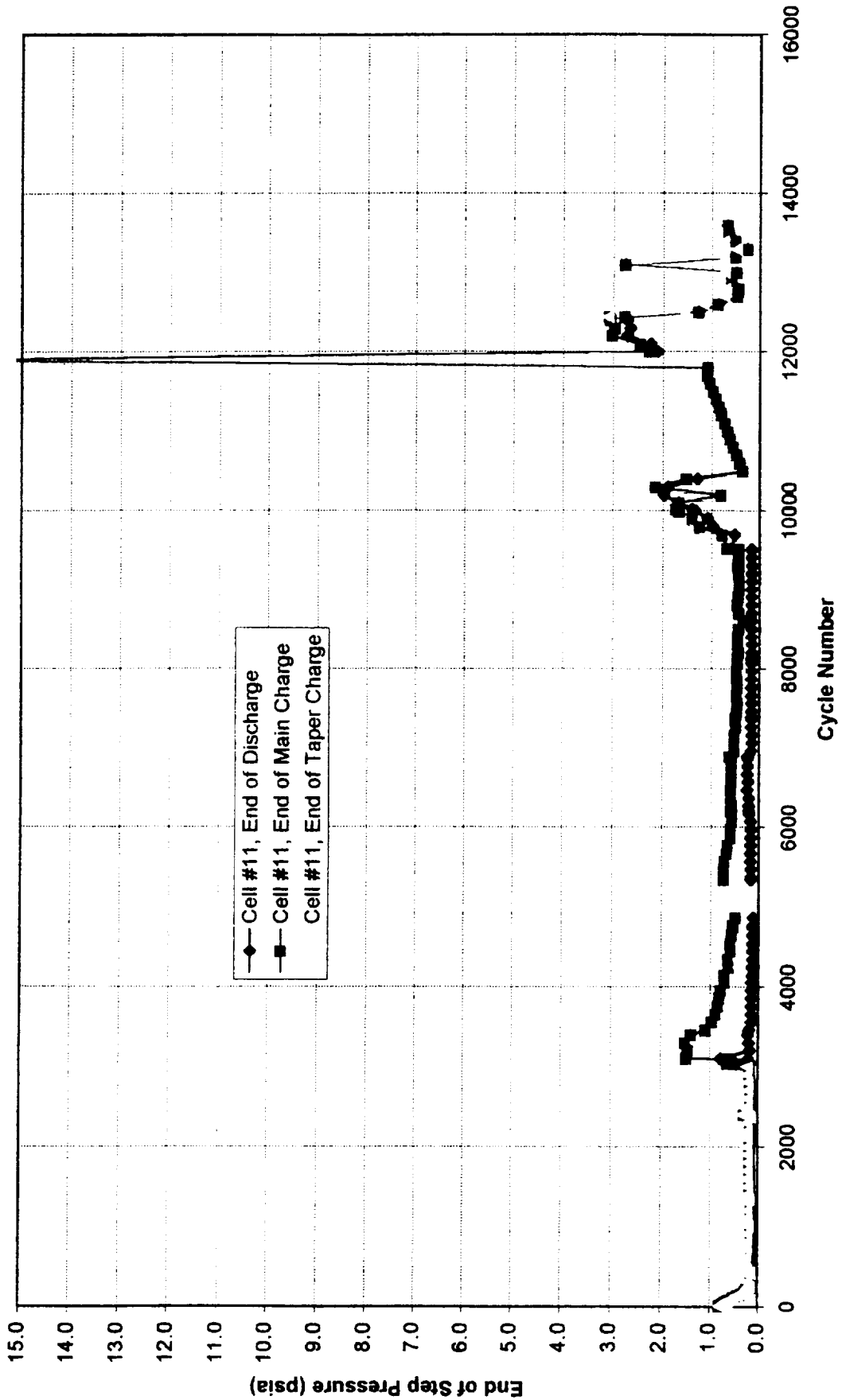
**-10°C Accelerated  
End of Discharge Voltage and Coulombic Charge Factor**



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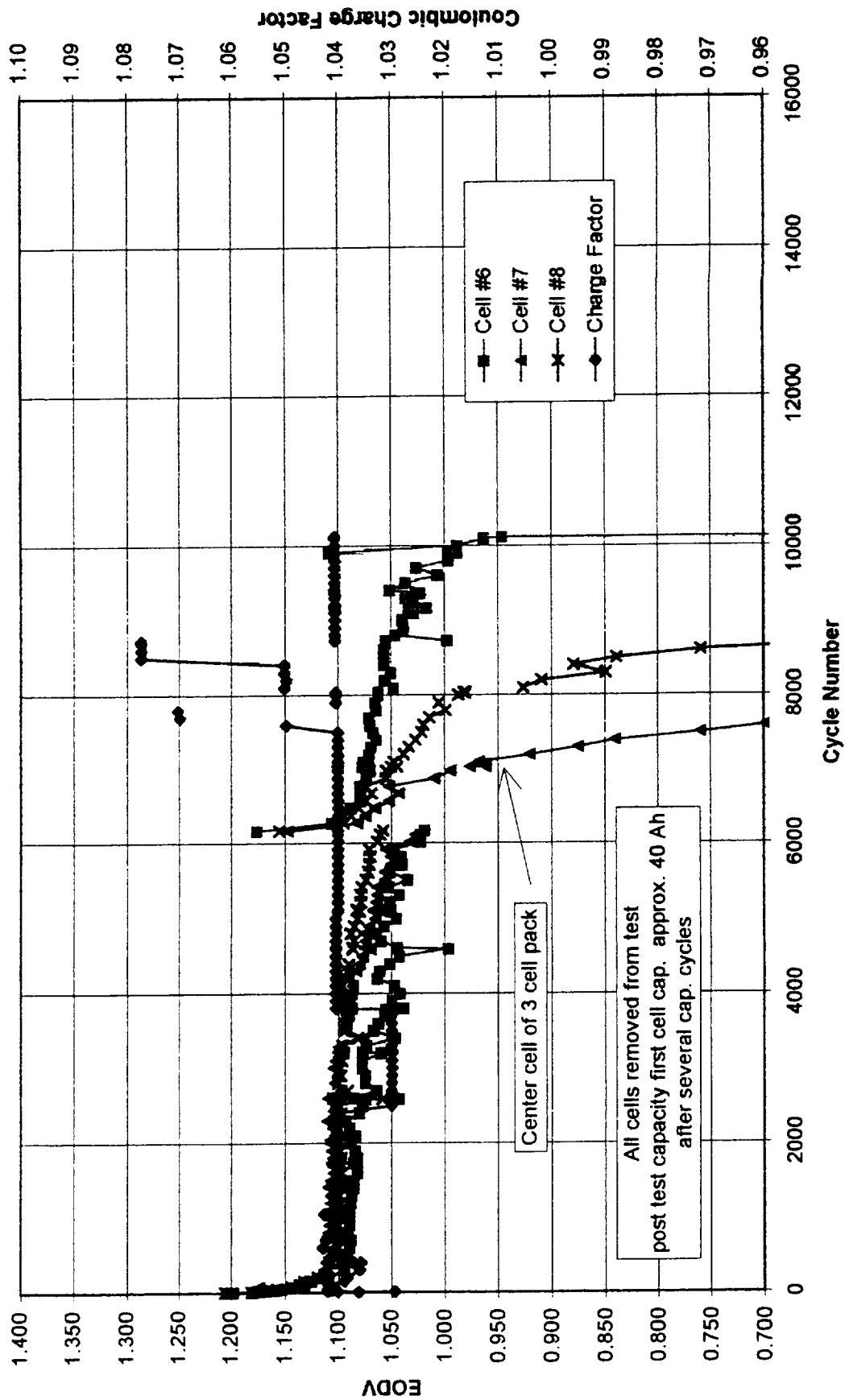
**-10°C Accelerated  
Internal Pressure**



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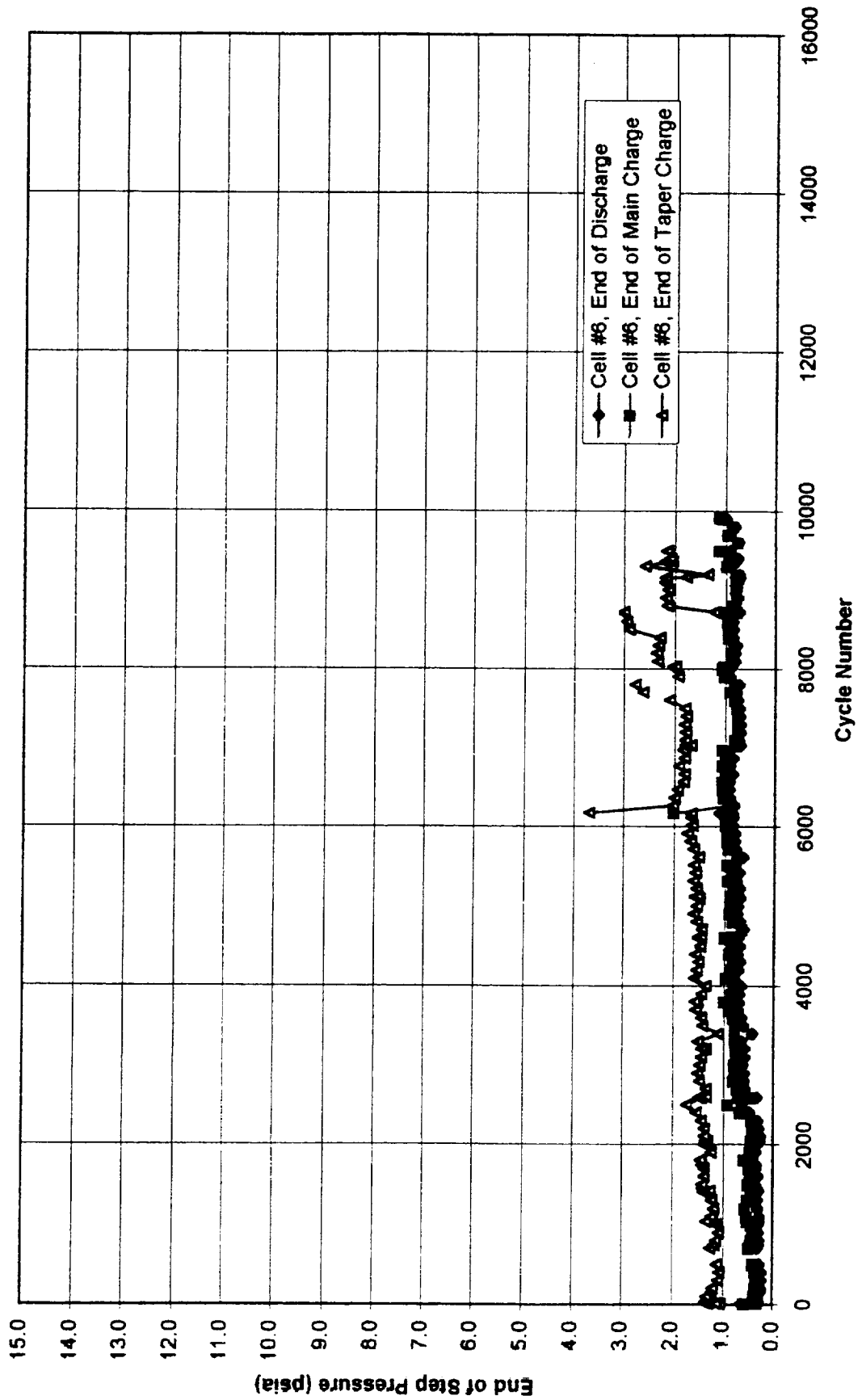
22 to 27°C Accelerated  
End of Discharge Voltage and Coulombic Charge Factor



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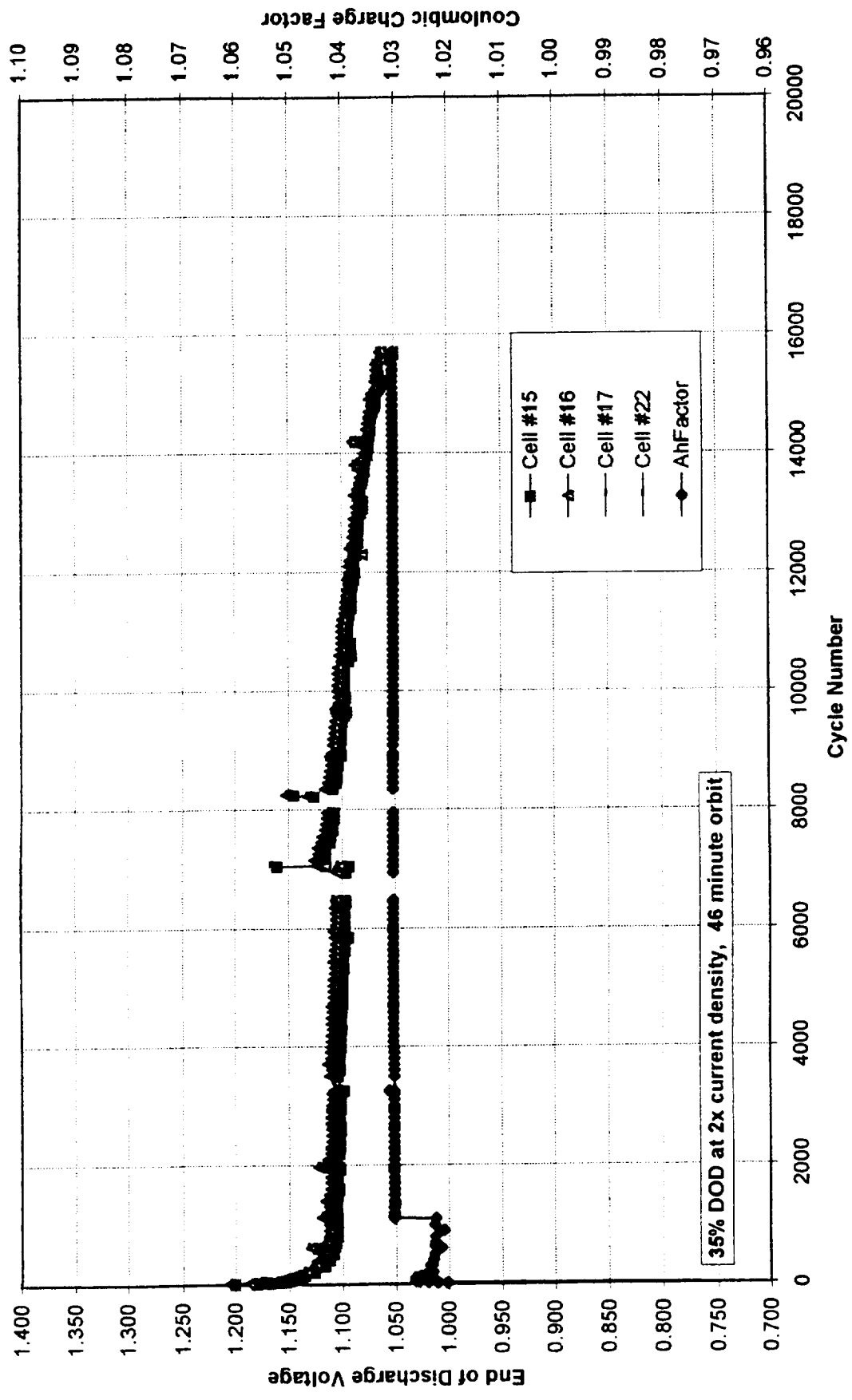
22 to 27°C Accelerated  
Internal Pressure



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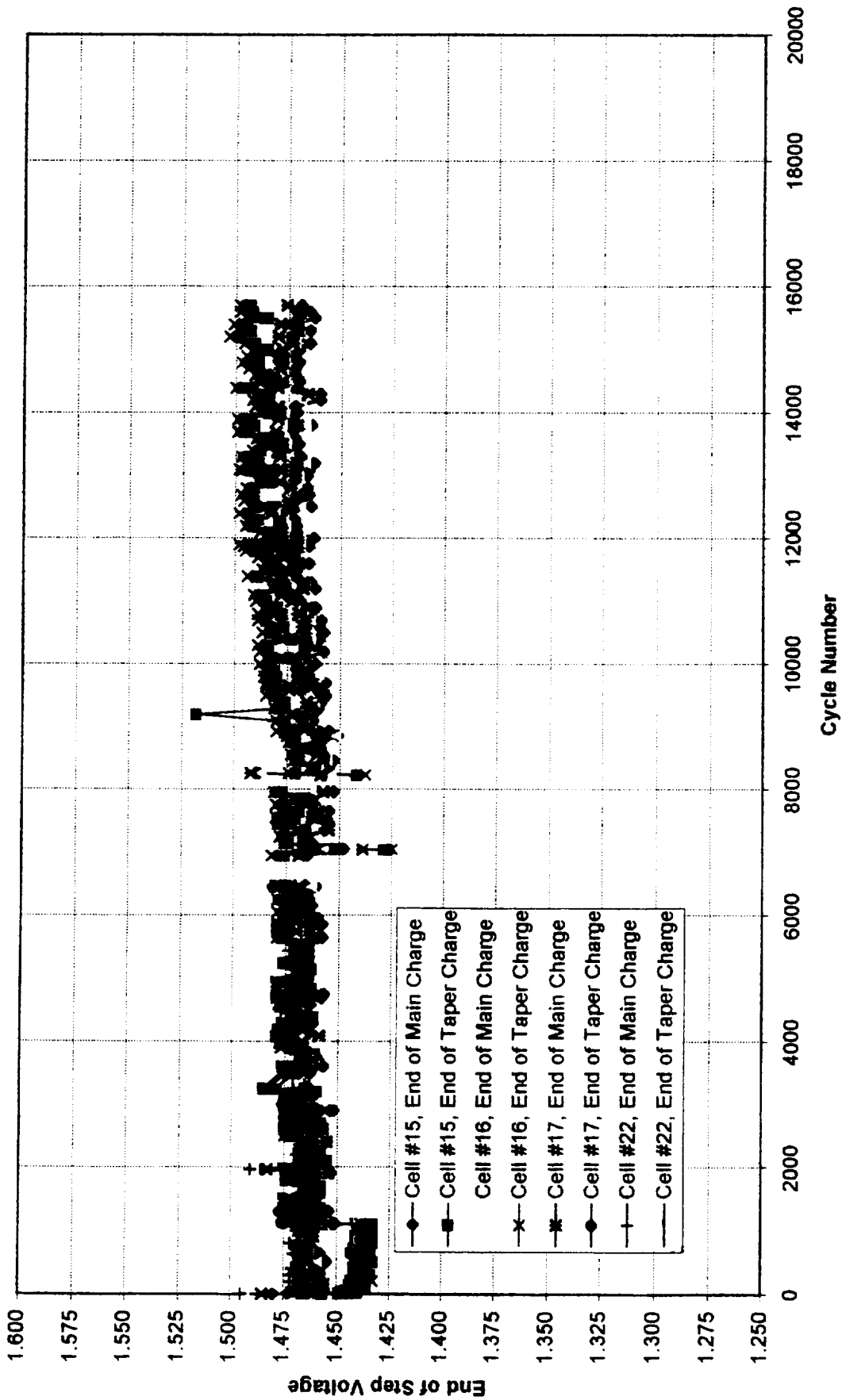
**10°C Accelerated  
End of Discharge Voltage and Coulombic Charge Factor**



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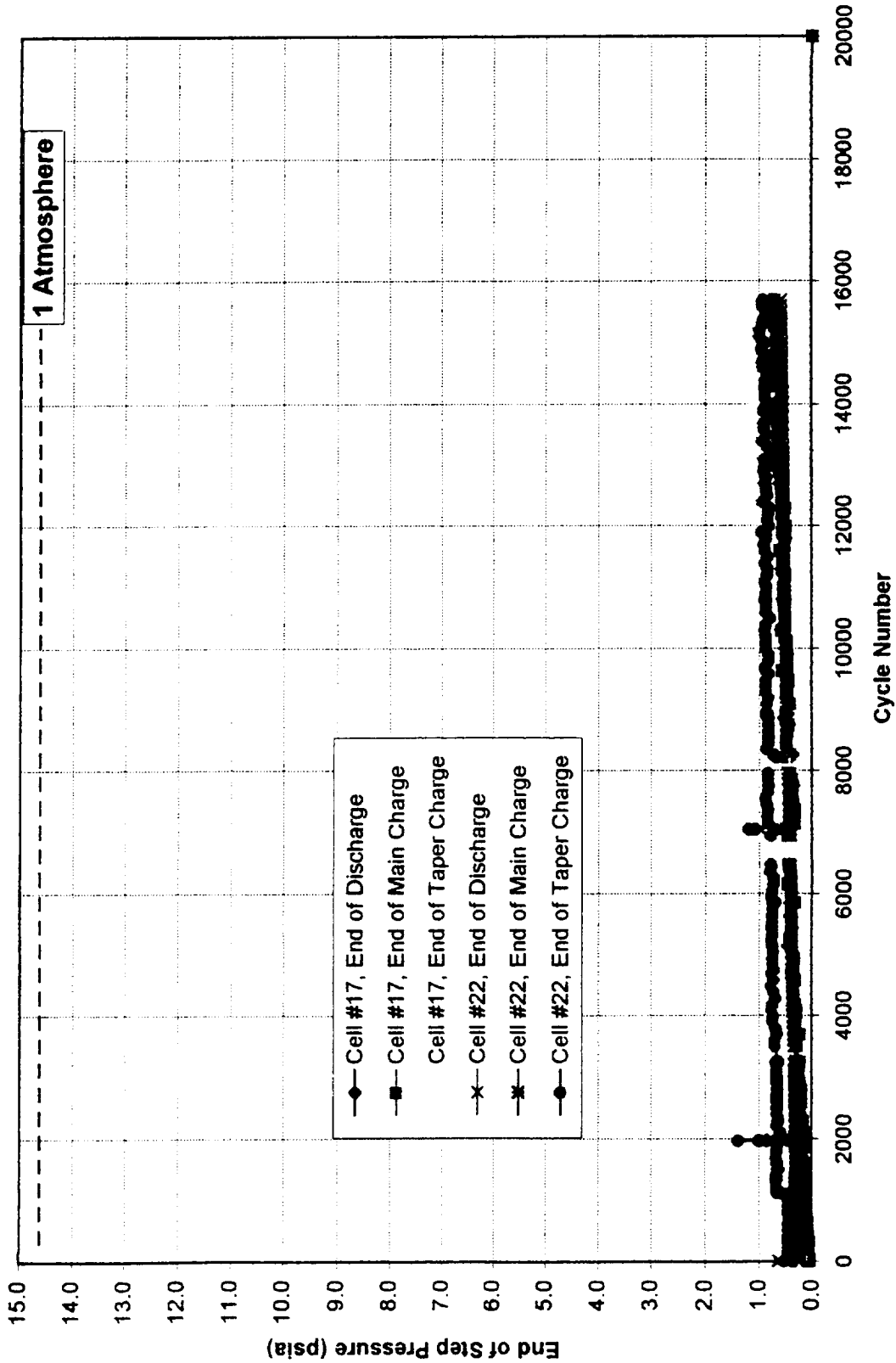
**10°C Accelerated  
End of Main and End of Taper Charge Voltage**



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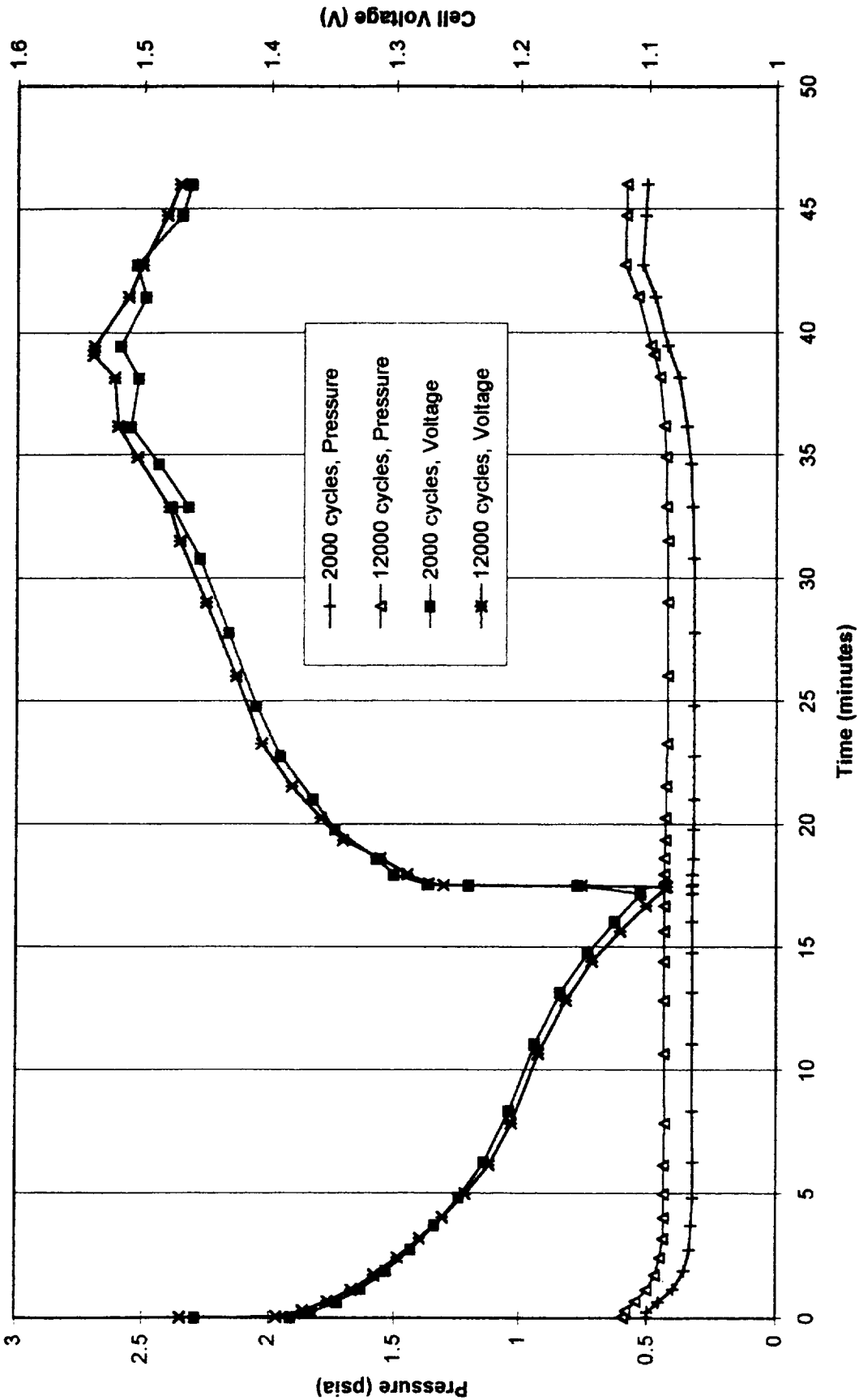
**10°C Accelerated  
Internal Pressure**



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**35% DoD Accelerated LEO, 10°C  
Voltage and Pressure Curves at Cycles 2,000 and 12,000**



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## **Conclusions**

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- **Sealed Ni-Cd cells are not limited to 50 Ah with the FNC design**
- **Energy Densities of 40 Wh/kg in a conservative high Cd, high electrolyte design have been demonstrated**
- **Uniform ATP data and LEO cycling performance is being demonstrated**
- **Internal cell pressures remain low under all conditions**
- **No conditioning is necessary under any LEO profile**
- **Accelerated LEO cycling exhibits performance well beyond traditional Space Ni-Cd cells**
- **The FNC shows promise for applications at higher charge and discharge rates, wider operating temperatures and deeper DOD than has been previously possible with traditional Space Ni-Cd cells.**
- **FNC offers lower cost, simplified system design and operating logistics, safer operation, comparable energy density to Ni/H<sub>2</sub>, resulting in a more economical choice for many applications**

