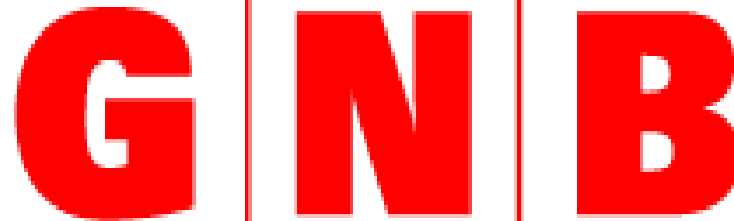


Ohmic Measurements: Advantages and Limitations

Robert J. Schmitt

The logo consists of the letters 'G', 'N', and 'B' in a bold, red, sans-serif font. Each letter is centered within a vertical red line that extends above and below the letter.

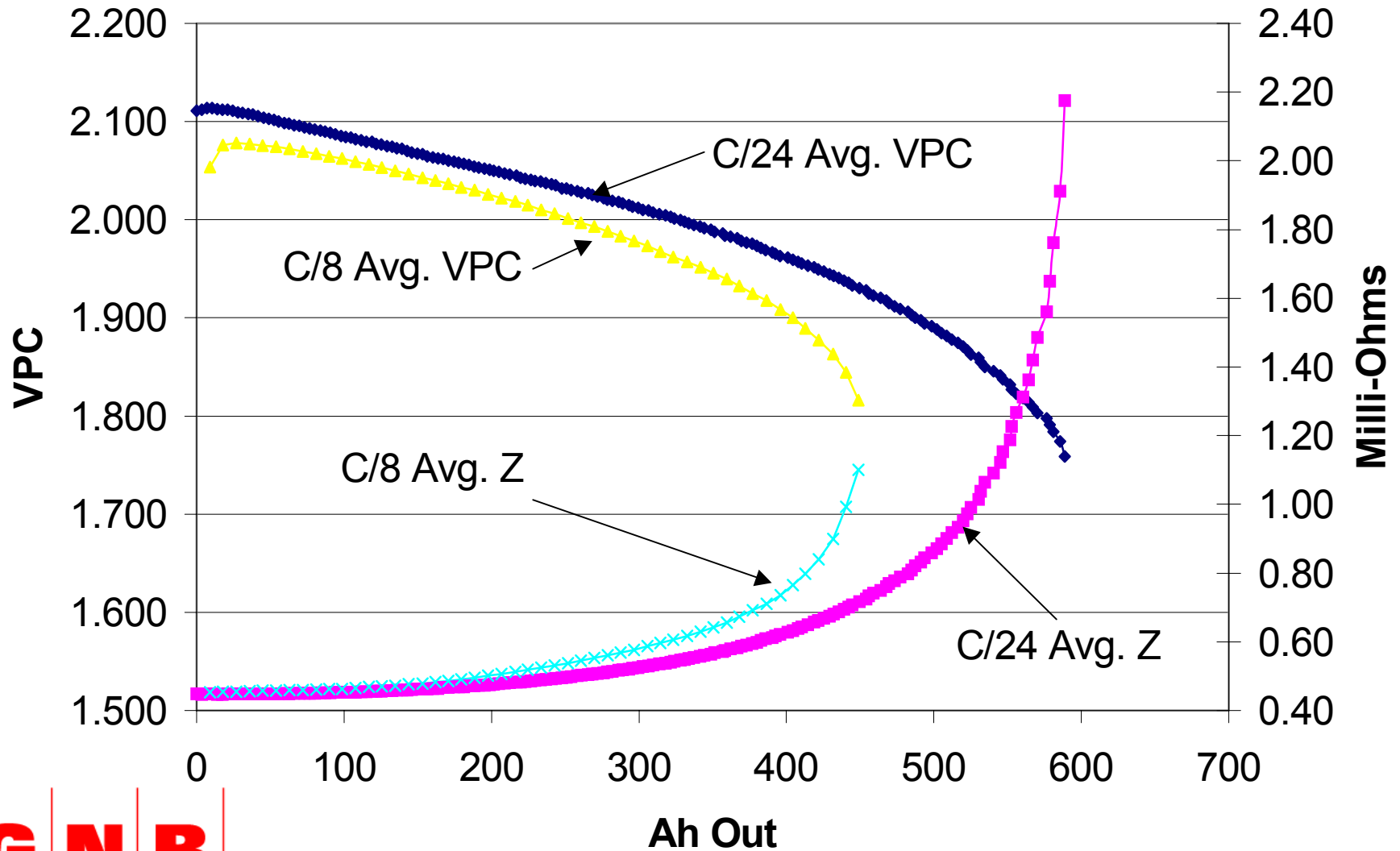
GNB Industrial Power

Death by Ohmic Measurement

- “This cell is 78.896% of Reference.”
- “This cell has always been low (high).”
- “Replacement criteria is 80% of reference.”

Some Background is perhaps in order. . .

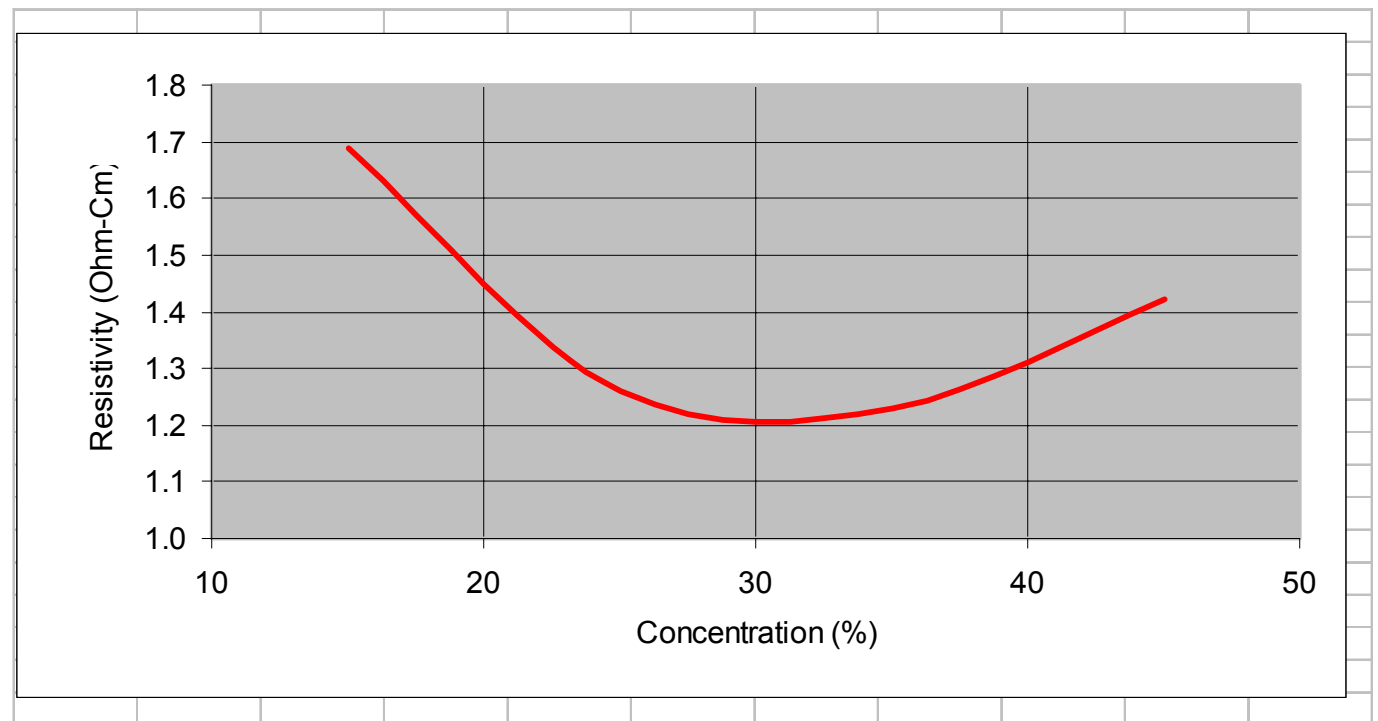
Avg. Voltage and Impedance During Discharge: 6-90A11



Impedance vs. State of Charge

- Resistivity of Electrolyte (H_2SO_4) Most Significant Component in Lead Acid Cell
- Changes in State of Charge Difficult to Identify Using Ohmic Readings

DOD	% ↑
50%	7%
75%	25%
100%	77%



As a Rule . . .

The larger the design cell capacity . . .

- The higher the conductance
- The lower the resistance, impedance

This makes sense.

- Larger cells have more acid and more robust paths for carrying current

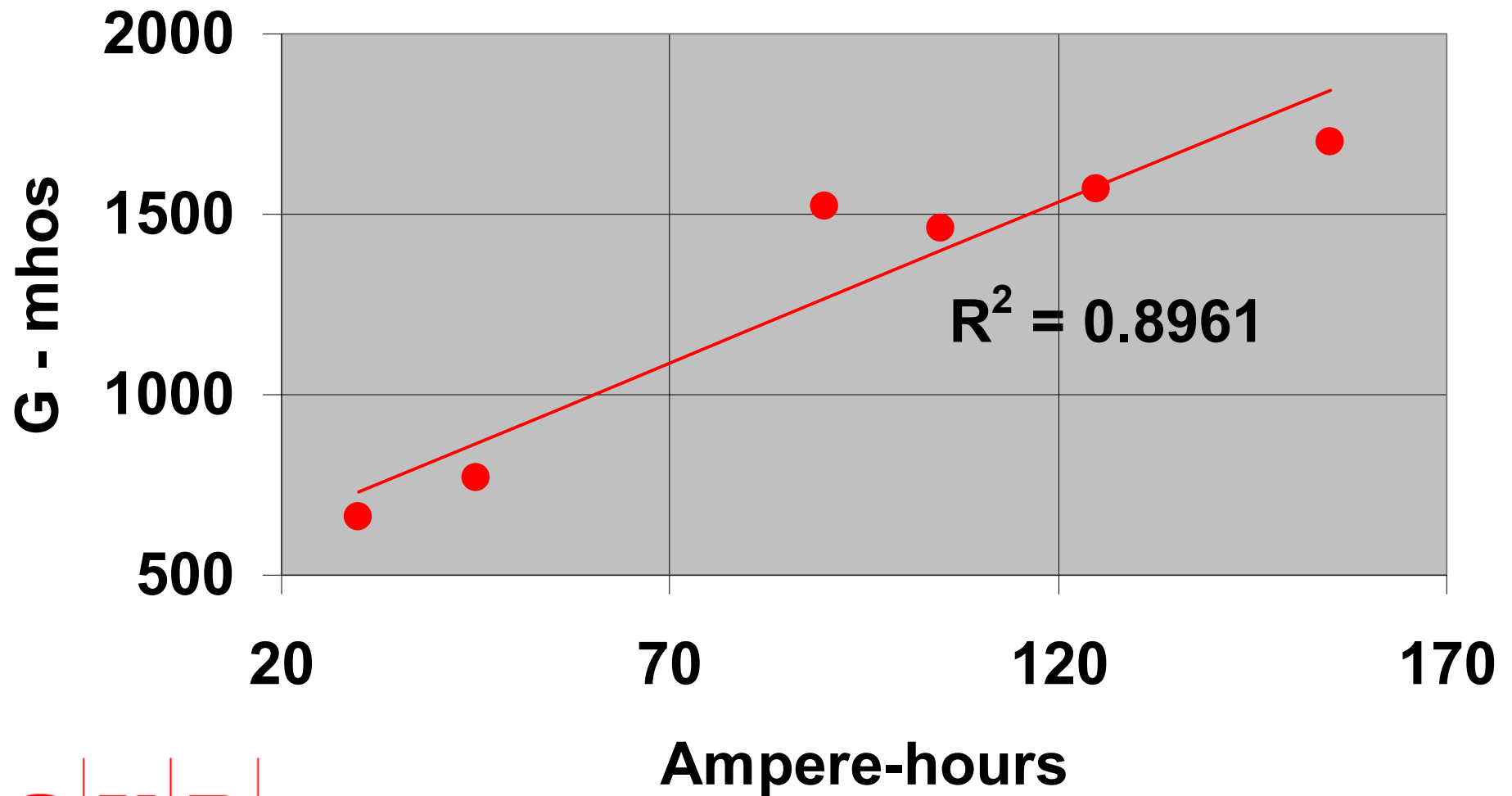


Monoblocs, Small VRLA:

- High Resistance
- Only 1 possible probe placement
- Automotive Division: Use devices to defer warranty
 - Look for approx. value; if off the mark, probable issue.
 - If on target, charge the battery
 - Meters have value BECAUSE they are insensitive to SOC



Monobloc: Capacity (Ah) vs. G

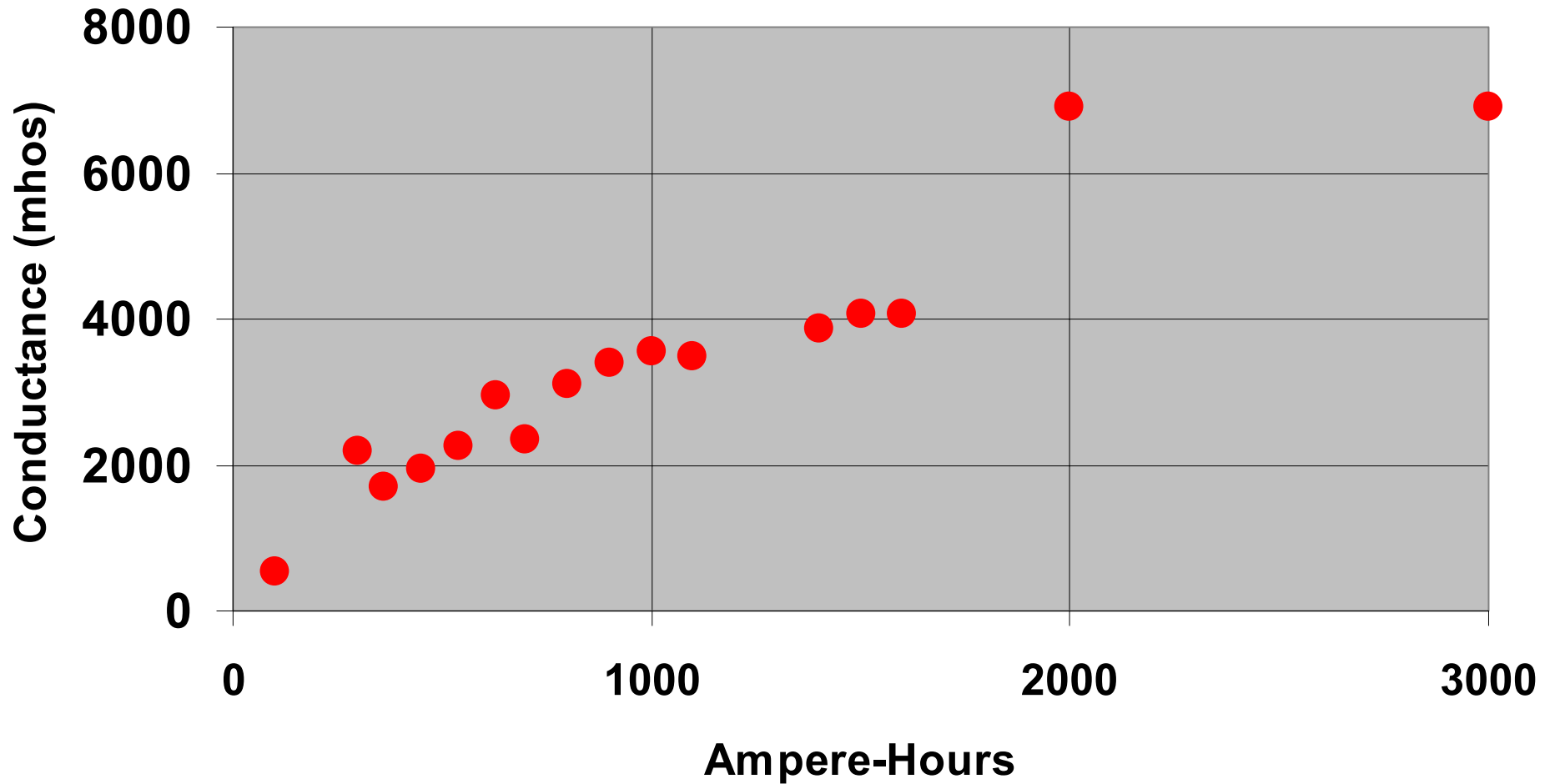


Large VRLA, Series-Parallel, Flooded

- Multiple Posts per Polarity → Multiple Probe Placement Possibilities
- Presence or Absence of Connectors Paralleling Posts – Have to Baseline off of Installed Configuration
- Unintended Paths for Signal Feedback
- Comparing “Buckets of Acid” - No Difference between New and 17 Year-Old?

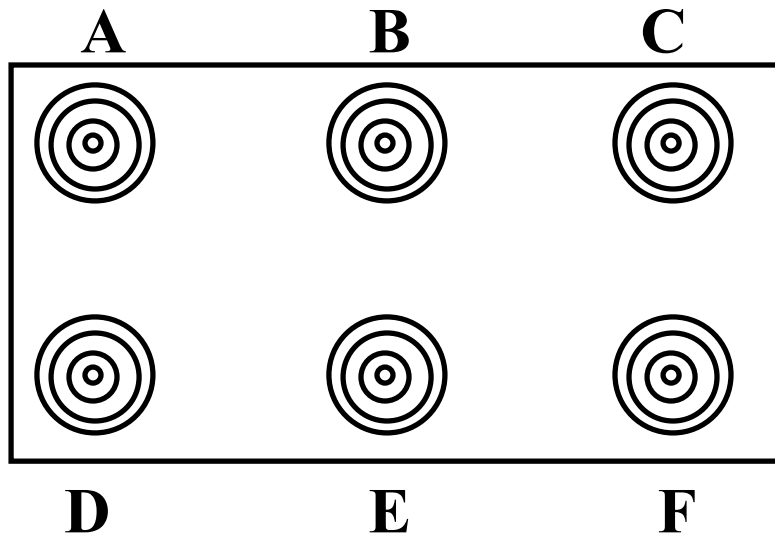


2V VRLA: Ah Size vs. G



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One Cell, Many Readings . . .



100A33 (1600-Ah)

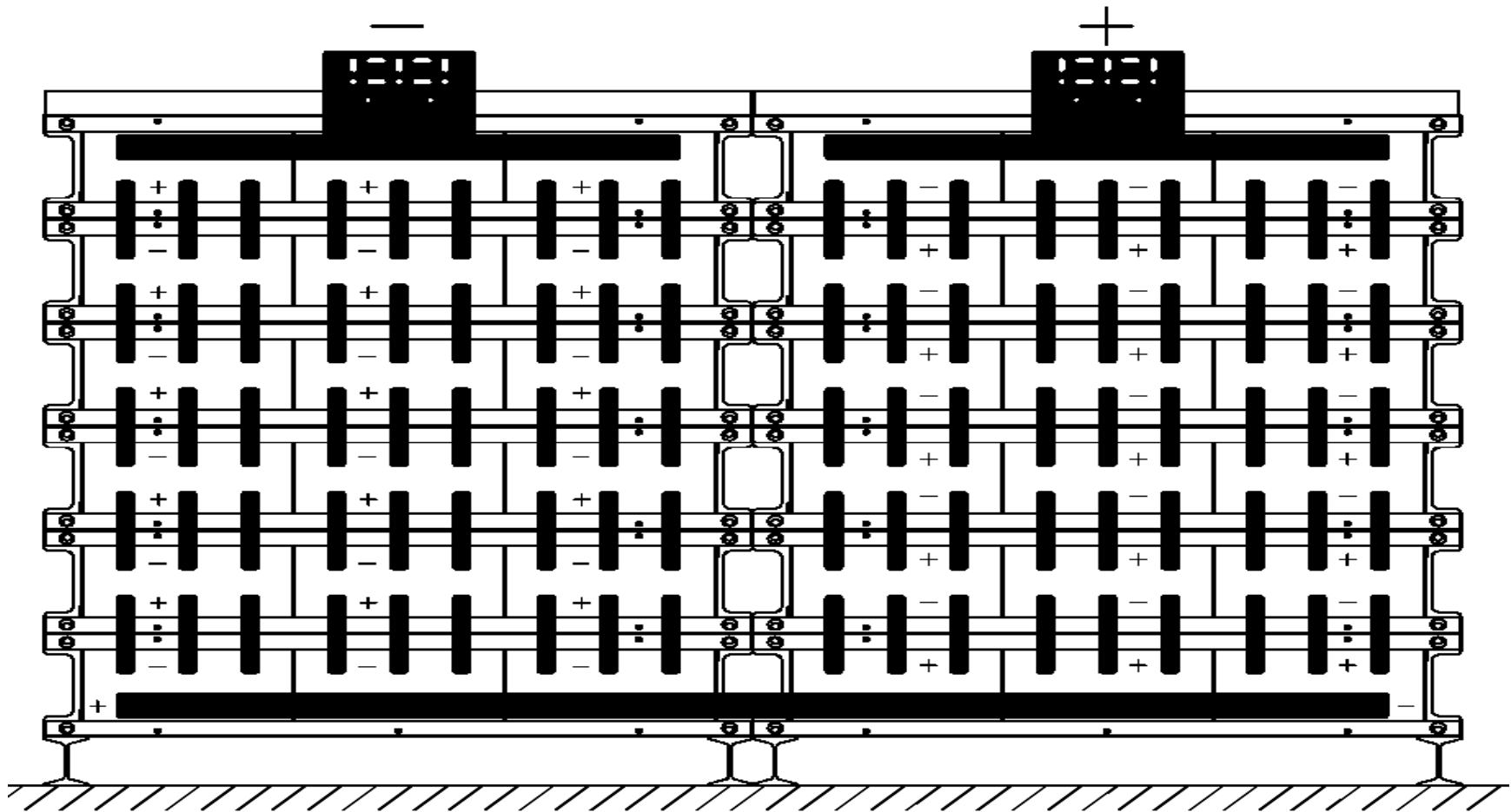
From	To	G
A	F	4186
C	D	4252
C	F	4494
A	D	4503
A	E	4818
B	E	5441

**30% Variation on
the Same Cell**



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Series-Parallel: Confuse-a-Meter



G N B

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And the Tech WAS Sober . . .

Cell	A	B	C	Cell	A	B	C
1	5751	5847	19999	13	6649	7022	6537
2	4748	5195	5118	14	6832	7074	6827
3	5233	5224	5335	15	6958	7407	6961
4	5233	5451	5434	16	6781	7340	6912
5	5172	5204	5279	17	6916	7186	6865
6	5242	5362	5138	18	7053	7358	6741
7	5108	5227	5098	19	6952	7169	6797
8	5674	5715	5583	20	6624	7103	6820
9	9293	11167	9067	21	6712	6960	6773
10	6877	7091	6809	22	6520	6812	6778
11	6785	7182	6675	23	6260	6949	6536
12	6518	8945	6568	24	9090	11392	13438

G N B

Characteristic Impedance Rise Values

Characteristic	Impedance Increase
1. State of Charge 50% DOD	7%
2. Accelerated Life Capacity >80%	50%
3. Intentional Dry-out Capacity >100%	24%
4. Compression Loss Capacity < 10%	125% (100% - 400%)
5. Natural Aging Capacity 100% vs. <80%	60%

• *Normal Variability of “Good Cells”:*
± 25%

G N B

In Our Experience . . .

- % Ohmic Magic Number \neq % Capacity
- For Multiple Posts per Polarity:
 - Probe Placement Matters
 - Connector Configuration Effects Readings
- Temp Differences between Sets of Readings Effect Data
- Series-Parallel Configurations “Confuse” Meters
- “Large” Ah & Flooded Batteries Overwhelm Most Meters
- Trend



The Way to Ohmic Nirvana

- Probe Placement: Establish a Convention & Have Everyone Follow It (Meter vs. Monitor)
- Measure and Record Temperature Each Time



Ohmic Enlightenment

- Be Wary of the Meaning of Large (>800-Ah) VRLA, Series-Parallel & Flooded Data
- Trending: The Road to Enlightenment
 - Establish Baseline (Ideally 2 – 6 Weeks after Installation)
 - Trend Cell-to-Cell (“Connector Effects”)
 - $\Delta > 25\%$ → Monitor
 - $\Delta > 50\%$ → Load Test Advisable



Thank You!