

CPF Lithium Primary Battery Testing
Chad Kecy
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Cell Description

The primary batteries used for future Coastal Profiler Floats (CPF) are comprised of 3B0036 High Rate DD Cell from Battery Specialties. This is their CSC93 series which has a Lithium Sulfuryl Chloride chemistry.

Chemistry	Sulfuryl Chloride
Construction	Spiral
Cell Size	DD
Length	111.5 mm
Diameter	33.5 mm
Cell Weight	213.0 grams
Lithium Weight	9.9 grams
Integrated Safety Fuse	Yes

Table One: Physical characteristics of the 3B0036 cell.

Cell Type	Primary
Open Circuit Voltage (25 degC)	3.93V
Nominal Voltage	3.40V
Nominal Capacity	26Ah
Maximum Continuous Current	4000mA
Operating Temperature	-20 degC to +93 degC
Self-Discharge Rate	<3% per year
Storage Temperature	25 degC
Discharge Condition	1000mA @ 23 degC

Table Two: Electrical characteristics of the 3B0036 cell.

Battery Description

Each battery pack is comprised of four 3B0036 cells in series. This gives an open circuit voltage of ~15.72Vdc and a nominal output voltage of ~13.6Vdc. The MBARI drawing number (and part number) for these quad cell batteries is 100221761. Each battery has 16AWG, 300V Teflon insulated leads with a length of 18 inches. The four cells are spot welded to each other and have been shrink wrapped together.

Load Testing

A single four cell battery was load tested using an electronic dummy load. The dummy load was set in constant resistance mode with a value of 12.8 ohms. For safety reasons, the test was paused whenever I was not present in the room. As a result, the test was completed over six individual periods ranging from three to five hours each. This resulted in some real-world variance in the terminal voltage between testing periods. Integrating the area under the discharge curve found the cells to have a 26.9Ah capacity. Derating this value for the CPF's operating depth due to decreased temperature translates to ~26Ah, the stated capacity. The temperature of the battery was recorded throughout the testing.

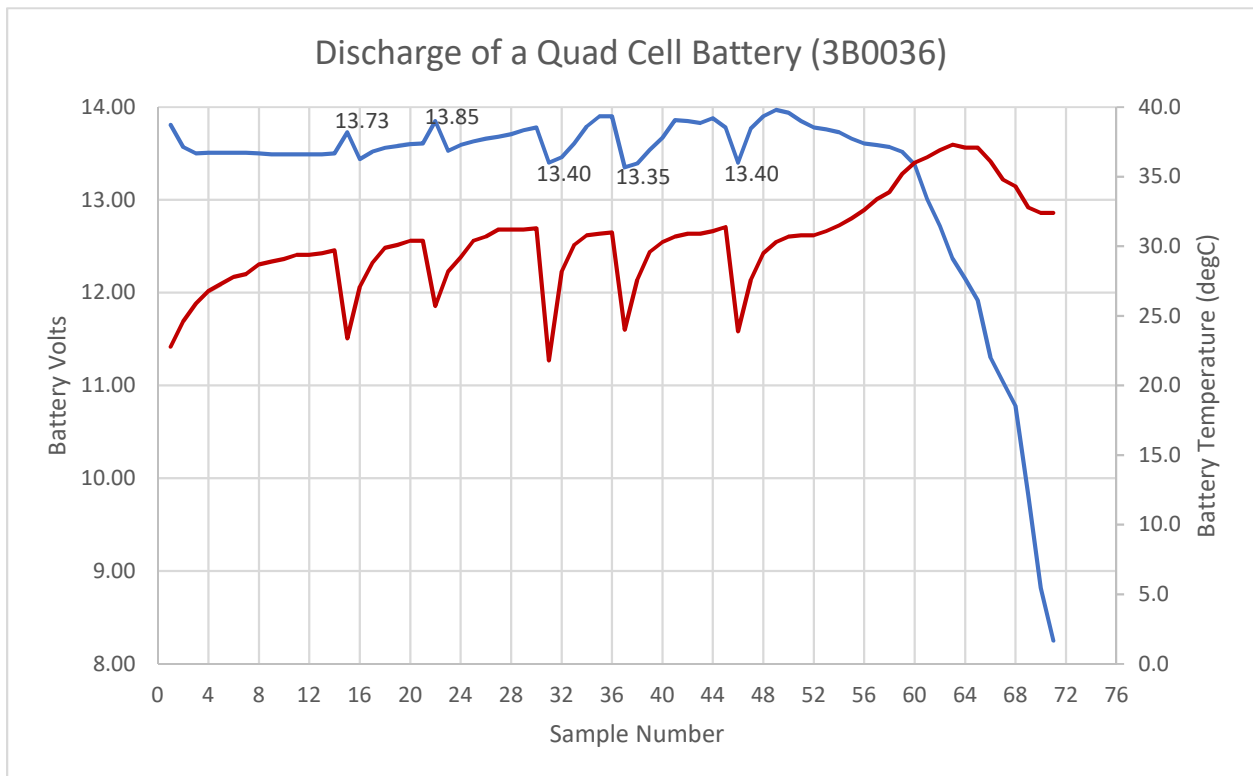


Figure One: Discharge curve of the four cell 3B0036 battery. The labeled data points (in blue) represent the voltage at the start of each separate testing period. The red data curve is the battery temperature in degrees Celsius.

Equipment Used

BK Precision 8500 Programmable DC Electronic Load
Fluke 87 Multimeter
Fluke 80TK Thermocouple Module

Constant Current Tests

A series of constant current tests were performed on a second, fresh battery. These were performed to capture the terminal voltage of the battery pack under differing load conditions. The three primary operating conditions of the CPF are Ascent/Descent (pump active), Sample, and Sleep. The approximate system current draw for the three modes are listed in Table three.

Mode	Current
Sleep	4mA
Sample	300mA
Pump On	8A

Table Three: System current draw during CPF operating conditions.

The three operating currents were included in the test, with the exception of the 8A mode. The maximum draw from the 3B0036 cell is 4A. In the actual deployment configuration, there will be four parallel stacks of eight cells in series. This will cause ~2A from each parallel battery to be drawn. Therefore, I measured the terminal voltage at 2A in a single battery to represent the 8A draw of the pump. Table four displays the battery terminal voltages under six separate load conditions.

Discharge Rate (A)	Vbatt	Vcell
0.004	15.45	3.86
0.3	14.43	3.61
1	13.71	3.43
2	13.20	3.30
3	12.76	3.19
4	12.33	3.08

Table Four: Measured battery voltages at various load conditions.

Equipment Used

BK Precision 8500 Programmable DC Electronic Load

System Capacity

The total energy capacity of the CPF was calculated by piece meal integration of the discharge curve. This resulted in 359.1Wh (1.29MJ) for a single 4S battery. Doubling the voltages and rerunning the numbers gave 718.1Wh (2.59MJ) for a single 8S battery. Multiplying the 8S capacity by four gave 2872.5Wh (10.4MJ). This number corresponds to roughly the quick calculation using an average terminal voltage over the same period.

Estimated Deployment Durations

Based on the terminal voltages measured during the constant current tests (see table four above), the total battery voltage was calculated. Then, based on the approximate operating time of each condition, the Ah consumption was calculated. Finally, the total energy needed for each condition was calculated.

Mode	Curr (A)	Vcell	Vbatt	Time (Hr)	Ah	Wh	Joules
Sleep	0.004	3.86	30.88	22.830	0.091	2.81	10116
Sample	0.300	3.61	28.88	1.000	0.300	8.66	31190
Pump On	8.000	3.30	26.40	0.167	1.330	35.00	126403

Table Five: Energy consumption of the three operating conditions of the CPF