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Load Testing and Charging of Large Lithium Batteries for Utility Applications

UCR Sustainable Integrated Grid Initiative (SIGI)

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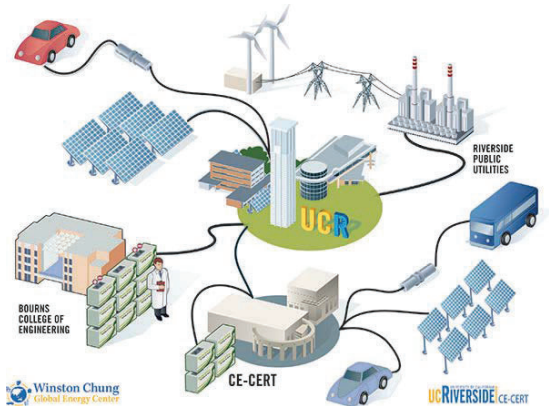
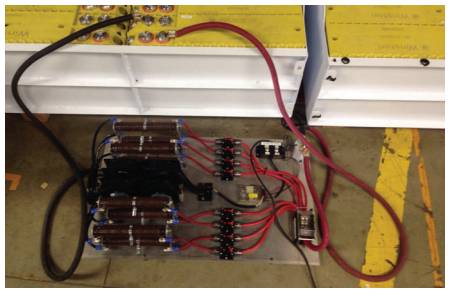
INTRODUCTION

Integration of the Lithium Yttrium Iron Phosphate batteries into Sustainable Integrated Grid(SIGI) Initiative requires each battery to be pre-load tested, charged, post load tested and balanced. To accomplish these tasks, researchers at the Winston Chung Global Energy Center have developed a streamlined process to load test, charge and balance the 1000Ah Lithium Yttrium Iron Phosphate batteries, before they are integrated into the grid.



Pre and Post Load Testing

Each individual battery must be pre and post load tested before being integrated in the system. First, the battery is connected to a 200A load as shown below:



Then, the initial voltage of the battery is recorded. Once a relay switch is turned on, the batteries begin discharging. After five seconds have elapsed the voltage is recorded. After 90 seconds the voltage of the cell and the discharge current are recorded. After 3 minutes, the final voltage of the cell is recorded and the relay switch is turned off to stop the discharge. The data is then used to calculate the internal resistance of the battery to determine its health. The process is performed before the batteries are charged and after the batteries are charged as a two part check on the health of the batteries.

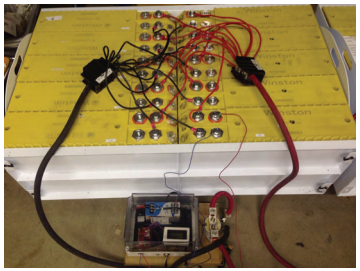
Verification

Shown below pre and post load data for a typical battery bank. Cell Y02213 had a high internal resistance when compared to the other cells in the bank. Because of this, the cell is determined to have bad health and swapped with a cell with good health.

CERT ID	Serial No.	Load Off Voltage	5s Load On Voltage	1.5m Load On Voltage	1.5m Current	3m Load On Voltage	Voltage Delta (Load Off vs 3m Load On)	Internal Resistance	Post Charge Load Off Voltage	Post Charge 5s Load On Voltage	Post Charge 1.5m Load On Voltage	Post Charge 1.5m Current	Post Charge 3m Load On Voltage	Post Charge Voltage Delta (Load Off vs 3m Load On)	Internal Resistance
533	Y01324	3.342	3.324	3.317	61.5	3.314	-0.028	-0.00046	3.726	3.660	3.513	64.5	3.474	-0.252	-0.00391
533	Y02286	3.342	3.325	3.318	59.6	3.315	-0.027	-0.00045	3.726	3.660	3.521	62.4	3.481	-0.245	-0.00393
533	Y01567	3.343	3.329	3.322	58.7	3.319	-0.024	-0.00041	3.726	3.670	3.517	64.0	3.475	-0.251	-0.00392
533	Y02258	3.343	3.327	3.321	58.3	3.318	-0.025	-0.00043	3.725	3.664	3.526	62.5	3.485	-0.240	-0.00384
533	Y02173	3.344	3.330	3.323	58.4	3.320	-0.024	-0.00041	3.726	3.670	3.525	62.3	3.481	-0.245	-0.00393
533	Y01845	3.343	3.325	3.319	60.0	3.315	-0.028	-0.00047	3.724	3.664	3.515	62.3	3.475	-0.249	-0.00400
533	Y01856	3.344	3.329	3.322	58.7	3.319	-0.025	-0.00043	3.725	3.660	3.522	61.8	3.482	-0.243	-0.00393
533	Y02213	3.345	3.248	3.244	56.8	3.241	-0.104	-0.00183	3.726	3.670	3.521	61.6	3.480	-0.246	-0.00395
533	Y02216	3.343	3.330	3.323	57.4	3.320	-0.023	-0.00040	3.726	3.672	3.526	62.3	3.486	-0.240	-0.00385
533	Y02211	3.344	3.327	3.320	58.1	3.317	-0.027	-0.00046	3.727	3.670	3.521	61.8	3.481	-0.246	-0.00398

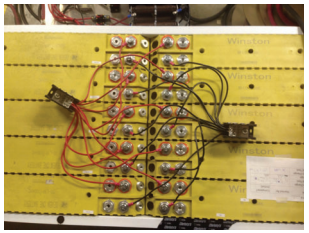
Charging

After each pre-load test, a battery bank consisting of 10 cells is charged in parallel. The voltage of the charger is set to 3.8 volts and the current and voltage are recorded at 15 minute intervals. A bank can take up to 30 hours to fully charge.



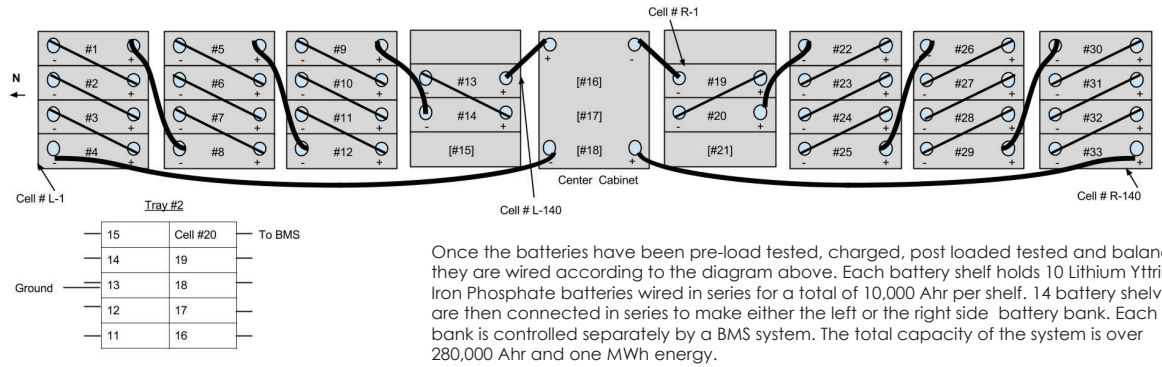
Balancing

After the post load test, the batteries are wired in parallel so that each cell will have the same voltage level when integrated into the system. This process may last 2-3 days.



Layout of Grid Connected One MWh Battery Energy Storage System at UCR

Electrical Connection Diagram



Once the batteries have been pre-load tested, charged, post loaded tested and balanced, they are wired according to the diagram above. Each battery shelf holds 10 Lithium Yttrium Iron Phosphate batteries wired in series for a total of 10,000 Ahr per shelf. 14 battery shelves are then connected in series to make either the left or the right side battery bank. Each bank is controlled separately by a BMS system. The total capacity of the system is over 280,000 Ahr and one MWh energy.

ACKNOWDGEMENT

Lithium Yttrium Iron phosphate batteries were donated by Winston Battery