# Battery Capacity Testing of Small, Large and Unusual Battery Systems

Presented By:

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Battery capacity testing is the best means of determining the reliability of a battery system and the only way to accurately determine its capacity. However, many battery systems are installed or manufactured with little consideration given to testing. Systems are installed in locations which are inaccessible or are configured in ways which defy testing. A few of the more unusual problems which have been encountered and overcome will be discussed in the following.

There are many types of load testing equipment in use today therefore, this presentation will be as generic as possible. This discussion will begin with a general overview of battery testing equipment, with an emphasis on how the testing equipment functions and how it can be adapted to difficult testing situations. Following the overview five testing problems will be discussed:

1. Multiple parallel strings of same type cells.
2. Recharging telecommunication batteries following load test.
3. High current discharge testing, 2000 Amps or more.
4. Series strings containing more than 200 cells.
5. Series / Parallel cell connections.

**General Battery Testing Considerations**
A battery capacity test consists of monitoring the electrical parameters of a battery while it is discharged at a controlled rate. The rate of discharge is determined by the manufactures specification. The desired result of a test is to determine if the battery will safely provide the energy required for its application. To control and monitor non standard capacity tests the following test system characteristics must be taken into consideration.

**Load unit resistance**
All load units are manufactured to operate within certain electrical limits which are a function of their KW rating. Resistive load units are manufactured using resistor networks which are connected through relays to provide the desired load. When all of the resistors are connected in parallel to the load they provide the least resistance, the highest current and highest KW load. The resistance of the load unit at maximum load is a critical parameter. This resistance is calculated by dividing the rated voltage by the rated current. The load units used by Powerscan have a full load resistance of .15 Ohms (105V / 700A ). It is essential that this resistance be known because it is used to determine the load unit capability when testing non-standard battery voltages. For example, what is the maximum load current one load unit can provide if the final battery voltage is expected to be 40.25 V (23 cells @ 1.75vpc) ?

I = 40.25 / .15 or 268 Amps.

In this example, if a current over 268 Amps is used the load unit will not be able to maintain the current when the voltage falls below 40.25 V. As the voltage decreases below this point the current will decrease proportionally. This is a common problem which occurs when the load unit runs out of resistors to place in parallel with the load. It becomes a critical consideration when performing lower voltage tests where long lengths of load cable are required. <u>When uncertain, connect all of the resistors and actually measure the full load loop resistance before beginning the test to insure the test configuration will provide the "end of test" current required.</u>

**Load unit KW**
The second parameter which must be considered is the maximum KW rating of the load cart. This usually becomes a factor when high current and high voltage tests are performed. When the load cart KW is exceeded, additional carts can usually be placed in parallel to increase KW capacity at the same voltage.

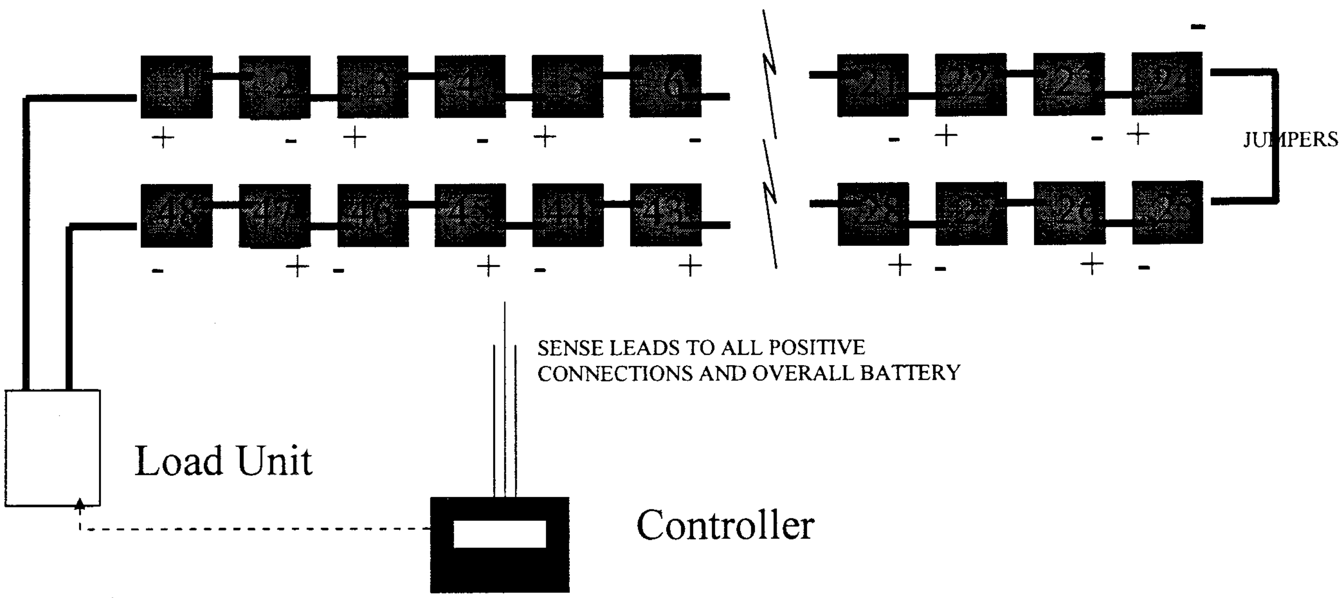
**Monitor capabilities**
The third parameter to be considered is the capability of the controller and monitor. The sophisticated control and monitoring systems available today can control the load over a wide range of constant current, constant KW , duty cycle profiles, while monitoring each cell in the battery string during the discharge. A typical system will monitor load current, overall voltage and 192 cell voltages.

**Testing Multiple Parallel Stings (same cell types)**
Telecommunication companies typically require power work to be performed between midnight and 6:00 A.M. Tests are commonly 4 hours in duration and the battery must be placed back on charge within this time window. This means that only one test can be performed each night and the systems must be fully recharged before the next string can be tested the following night.

Most large telecommunication facilities have several redundant parallel strings of 24V and 48V batteries or a mix of both battery voltages. These parallel strings are often of the same make and model cell. If so, the following steps may be taken to reduce the time required to test the batteries.

1. Determine the plant load and check the manufacturer's specifications to calculate how many strings are required to provide the required backup time for each section of the battery plant
2. Remove the redundant strings from service (those strings not required to support plant load) two or three strings at a time and connect them in series as shown below:

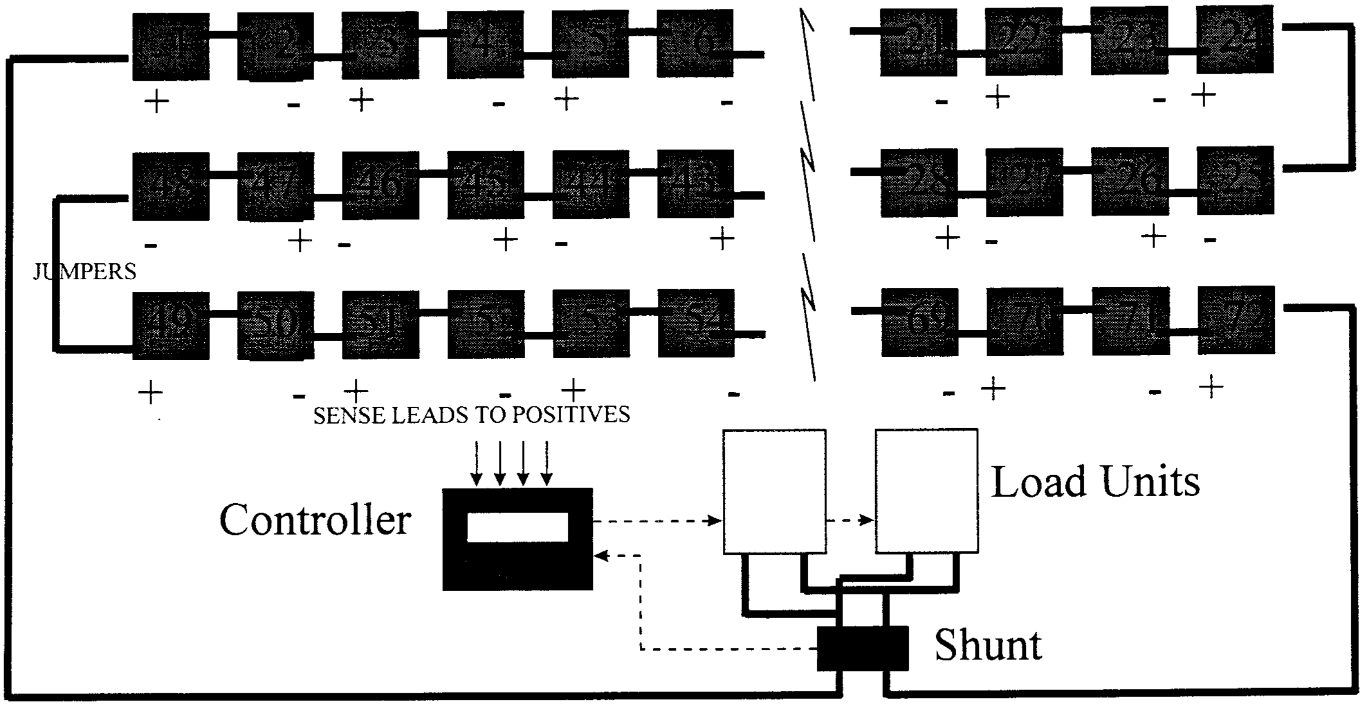
NOTE: MAX CURRENT AT 42V = 42/.15 = 280A
MAX CURRENT AT 84V = 84/.15 = 560A




Battery strings with the same type cells but different voltages may be mixed as long as the combined string voltage is within the limits of the load units.

The following is an example of three 48V strings connected in series and tested as one unit. Note that a second load unit is connected in parallel to provide more capacity and a shunt is used as a connecting point.

## Testing three 48 Volt Strings connected in series



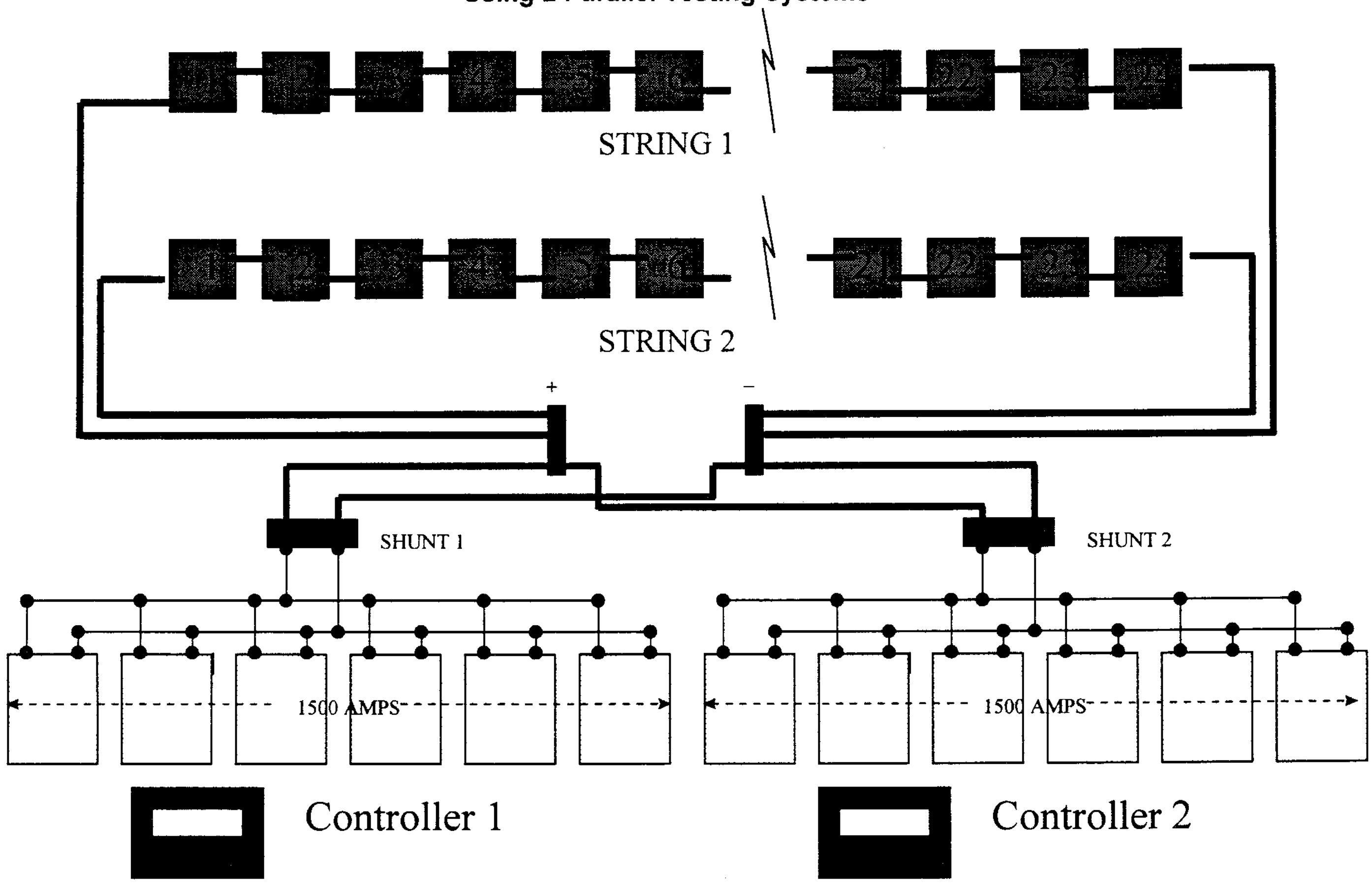

**Recharging telecommunication batteries following a load test**
After the batteries have been discharged their voltage will be near 45 V. They must be recharged to within .5V of the plant voltage (52.5 V) before they can reconnected. One way to accomplish this is to remove a rectifier from service and disconnect its DC output cables. Load testing cables are then used to tie the rectifier directly to the batteries. When the rectifier is no longer in current limit mode it can be adjusted to within .5V of plant voltage and the batteries can be paralleled back into service. The plant will now provide the final charging current.

**Recharge Monitoring**
Customers often like to see a battery recharge curve. Battery voltage, recharge time and current can be recorded by setting the system up for a normal test and by running the charging cables through the shunt. The monitor system is then programmed to run several zero current tests. This will cause it to record the system parameters which can be used to generate a recharge graph.

**High Current Discharge Testing**

Powerscan recently performed a 3000 Amp four hour discharge test on two 48 V parallel strings of HCT3700 cells. The test was performed at Powerscan's Dallas facility, to simulate actual site discharge conditions. The maximum load that could be placed on each load unit was 280 A. The test was performed by running two simultaneous tests with six load units each, using two controllers. The following is a block diagram of the test setup.

**3000 Amp 48V Test**
**Using 2 Parallel Testing Systems**



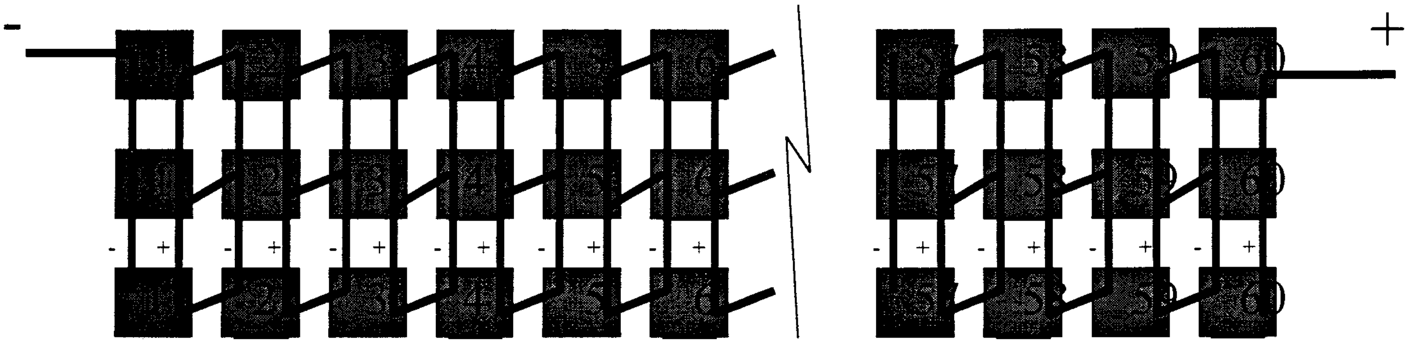

**Testing battery strings with more than 200 cells**

One of the more common testing problems occurs when the number of cells to be tested exceeds the capability of the monitoring system. For example, the battery has 250 cells and the monitor has 192 voltage sense leads. One alternative is to break the system apart and test each part separately, requiring two or more tests. Another way to overcome this problem is to monitor every other cell. While under load, if the voltage of one pair of cells decreases disproportionately, both cell voltages are measured manually. It is useful to leave a meter connected to the suspect cells so they can be continuously monitored. When using this approach start measuring low voltage pairs early in the test, don't wait until the cells reach a critical voltage to determine which one is defective.

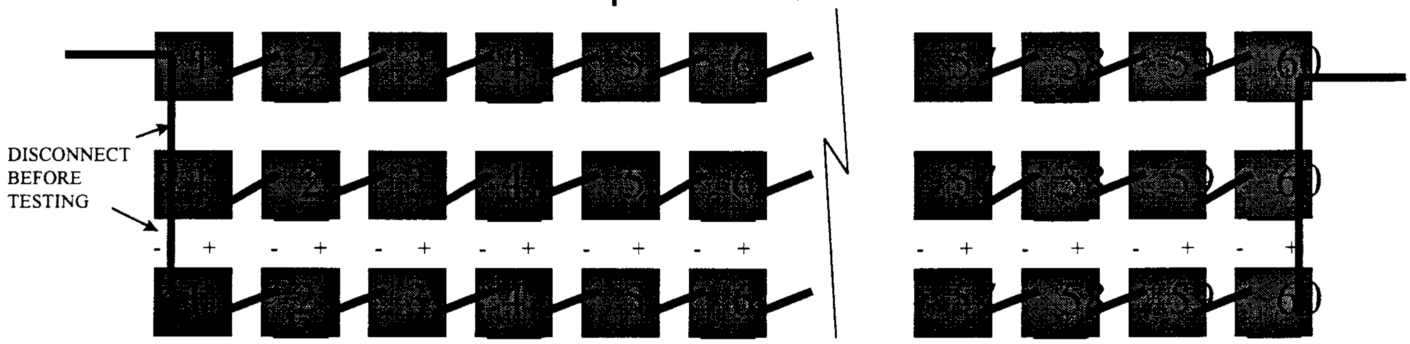
**Testing cells connected in series / parallel circuits**

Series / Parallel cell circuits create a testing problem which cannot be solved easily. Individual cells in a series parallel circuit can only be tested if the interconnecting paralleling links are disconnected. If this is not possible, a pass fail test is probably the best alternative. The terminal voltage can be monitored and an overall average capacity can be determined. An example of a series / parallel cell configuration is illustrated below:

### 120V System Connected in Series / Parallel



### Equivalent circuit




The equivalent circuit shown above could be easily tested by performing three 60 cell tests. Two strings could be left online while the third is tested. The second alternative is to connect the three 60 cell strings into one 180 cell series string and perform one test.