SERIES TESTING OF AIRCRAFT NICKEL-CADMIUM BATTERIES

Note:
This document is a guideline for the use of Charger-Analyzers manufactured by JFM Engineering for the testing and certification of aircraft Lead-Acid batteries. CMMs and Battery Manuals from manufacturers must always be consulted to determine the exact conditions required to service their particular batteries.

Warning:
Batteries are capable of very high discharge currents. Protect from shorts!
Batteries contain electrolyte that can produce chemical burns, Exercise caution!
Always wear protective equipment and use appropriate tools.
Insure that battery testing is performed in well ventilated areas.
Only Sealed Lead-Acid batteries can be in the same environment along with Nickel-Cadmium Batteries.
Vented Lead-Acid types need their own, well ventilated area

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1. Introduction:

Can Nickel-Cadmium Batteries be charged in series?
The answer is both yes and no as it depends entirely on the charging method and equipment.

2. Operation Description:

Nickel-Cadmium batteries can be charged in series if, and only if it is done with constant current. A more complete answer, however, depends on the purpose of the charging.
If the purpose is to simply charge a discharged battery, any method available will do (will have to do).

But, if the purpose is to charge a battery for test purposes (to determine if the battery is airworthy) then constant current is the only way, as it is established by the manufacturers of the batteries.

When a battery is charged in constant voltage (or other voltage dependent methods) then the individual cells that make up the battery can easily become imbalanced[1]. This is one of the reasons why a periodic deep cycle is needed.

When a Nickel-Cadmium battery is charged at constant current, all cells are free to develop a voltage that becomes indicative of their charge acceptance. It is for this reason that Nickel-Cadmium batteries can be charged perfectly well in series[2].

Why charge batteries in series? Strictly for efficiency reasons. The typical charge time for a Saft battery is 6 hours[3], therefore, if two batteries can be charged simultaneously, there is a significant gain in time.

Charging two batteries in series requires a higher capability in the Charger-Analyzer and a corresponding higher safety margin. The Superseder/MasterCharger was designed for both. It can provide constant current charging from one cell up to 50 cells and it can only output current while connected to a battery (no dangerous "hot" terminals).

What about the task of measuring 40 cells, not just 20?

Yes, measuring the voltage on each cell is laborious and error prone but it can be done (not just on 20 cells but on all 40 – there is plenty of time). To alleviate this burden, the BTAS16 Battery Management System was designed to automatically take all necessary measurements, accurately and efficiently (see http://jfmeng.com/btas16.htm).

[1] Note that Lead-Acid batteries can also suffer from the same imbalance problem, although to a lesser extent.
[2] Note that a typical aircraft battery can be looked at as a series string of 20 individual batteries.
[3] Two hours of Main Charge (C/2) and four hours of Topping Charge (C/10).

3. What about discharging two batteries?

Discharging of two batteries, for the purpose of Capacity Testing, presents a different situation. At constant current, it basically does not matter how many batteries are connected but there is a power dissipation limitation.

The current model of Superseder/MasterCharger is limited to a maximum of 60A for one 24V battery or 30A for two 24V batteries. At a higher voltage and/or current, the heat dissipation will exceed the cooling capability in the load banks.

Yes, it is possible to lower the current and extend the time to accommodate batteries that would otherwise exceed the power dissipation limit, but it may be necessary to account for possible performance differences at the lower current.

But, there is a more fundamental issue here. Capacity testing is not simply based on a battery terminal measurement; it requires that all cells be measured, because the battery will fail capacity the moment that any one of the cells fails capacity, thus requiring rapid measurement of all cell voltages.

It is already quite demanding to quickly monitor 20 cells, let alone 40 of them.

The BTAS16 system again comes into play by providing an easy method to measure all cells, not just 20 but 40!

4. Summary:

4.1. Series charging of Nickel-Cadmium batteries is perfectly normal provided that it is done with constant current.

4.2. Series discharging, however, is not that simple, as it is affected by other factors that limit the gain in testing efficiency.

4.3. The following articles, available from the JFM Engineering Website, will provide additional information on aircraft battery testing:

- 4.3.1. Aircraft Battery Testing Definitions and Notes
- 4.3.2. Battery Testing Guidelines
- 4.3.3. Testing Intervals for Aircraft Nickel-Cadmium Batteries
- 4.3.4. The Importance of Water Levelling

5. REVISION INDEX

Table 1 - Index of Revisions

REVISION	DATE	NOTES
V3.0	30 September 2014	Rewrite
V3.1	11 October 2014	Minor text formatting corrections