Accuracy and Efficiency in the testing of Aircraft Batteries

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Introduction:

In the operation of a Battery Shop, where aircraft Nickel-Cadmium[1] batteries are tested and certified, there are two fundamental requirements that must be met: Accuracy and Efficiency.

Accuracy is fundamental because battery testing is an exact process. There are tangible numerical limits that determine pass fail conditions.

Efficiency is fundamental because battery testing, being a laborious process, requires a careful choice of process and equipment that will permit meeting the manufacturer's requirements while minimizing the expenditure in equipment and personnel.

There are two most relevant aspects of the battery testing process: Equipment and Process.

Equipment comprises the Charger-Analyzer and a variety of accessories such as meters, resistors and shorting clips, plus water dispensers and syringes. The Process on the other hand, comprises all the procedures and individual steps that must be followed to meet the battery testing requirements.

Determining the choice of equipment starts with a review of the testing and performance specifications given by manufacturers in their general manuals and individual battery CMM's. Batteries must be tested for charge acceptance and capacity, where charge acceptance is the ability of the battery to receive current and consequently to develop voltages within acceptable limits (note that battery temperature is also a limiting factor in the charge acceptance criteria), while capacity is the ability of the battery to deliver the rated current for a minimum time while remaining above a minimum voltage.

Although any form of charging can be used to charge a battery and any form of load can be used to test a battery, it must be pointed out that it is not just a simple matter of charging or loading a battery. Both tests require exacting conditions of current, voltage, time and temperature, hence, establishing the need for precision performance.

The must important performance characteristic of the Charger-Analyzer for Nickel-Cadmium batteries is constant current[2] because that is how testing is specified by the battery manufacturers. The charge is done with constant current and the same holds true for the discharge. Although other charge methods are mentioned, the only method which is fully described, and hence the method of choice, is constant current.

Most Nickel-Cadmium batteries require a two step constant current charging, the first one, called Main, is used to replenish the charge taken out during the Capacity Test and the second one, called Topping, is to "top-off"[3]. the battery and to test that each of the cells reaches the proper charge voltage[4]. It is during this Topping Charge period that temperature must also be observed[5]. In addition, at the end of the Topping Charge period, the level of the electrolyte is verified and distilled water added as needed.

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[1] Although this article refers mostly to Nickel-Cadmium battery testing, it is equally applicable in importance to Lead-Acid batteries and to batteries of other technologies, including those called "maintenance free".

[2] Constant Current means that the charging current will remain at the required value independent of battery voltage and power line voltage.

[3] The charge process is not only not 100% efficient, it drops as the cells charge up. Therefore, it is always necessary to deliver more charge than has been taken out to insure a full charge, typically 40% more.

[4] Cells that do not develop the proper charging voltage indicate a failure of the separator or insufficient charge. Furthermore, cells that do develop a proper voltage but later show a drop do so because of separator failure (there is also a temperature rise).

[5] Nickel-Cadmium batteries are not expected to warm-up significantly during the charge process. If they do, it could mean that the cell separators are failing or that the internal resistance of the cells is high (worn out cell) or that the battery is being overcharged.

Additional characteristics required of Charger-Analyzers include intuitive and user friendly programming of the test parameters such as current, time and voltage/number of cells, all with the necessary accuracy and stability for the validity of the tests. When controls are easy to understand and use, training time is reduced and the chances of erroneous settings are also reduced.

The Process for battery testing is straightforward but it is laborious, requiring great attention to detail. Testing procedures are well defined in battery manuals, so the only special requirement is the selection of the equipment to properly meet the test requirements. As stated above, the choice of equipment will determine how well the test requirements are adhered to and, as described further, how much work will be required by the operator.

Note that failing to observe proper testing requirements can and will result in premature failures and/or excessive replacement of batteries and cells, both having a significant impact in the cost of battery maintenance and in the operation of the aircraft. Improper battery maintenance could easily result in costly AOG situations or scary in-flight battery overheating.

Battery testing is laborious because of the many steps that are required. From the readings taken to determine the "as received" condition to the multiple cycles of charge and discharge required to restore the capacity of the cells.

The most involved part of the testing is the multiple measurements that must be performed. For a typical 20 cell Aircraft Nickel-Cadmium battery this means twenty measurements of cell voltages in addition to the battery voltage at its terminals for every step in the test process.

Although readings at the end of the charge and discharge tests constitute the bottom line for pass/fail determination, intermediate readings are fundamentally useful because they provide early warnings of impending failures.

The end result is that even without intermediate readings a typical battery test sheet can have one hundred or more individual readings. Clearly, a source for transcription errors in addition to the tediousness of measuring and recording[6].

[6] Note that the measurement of all cell voltages is not optional. It is a fundamental part of battery testing requirements and it is well specified in battery manuals and CMM's.

Automating the process:

As stated in the introduction, there are two fundamental parts of the battery testing process: the equipment to charge and discharge the batteries and the measurement of battery and cell voltages.

Although there are opportunities for automation at both ends, automating the process of measuring battery and cell voltages is the most important one for it alleviates the problem of time consuming and error prone manual measurements and recording.

Automation of the charge/discharge process, on the other hand, is not as important because individually it is a lengthy process, particularly in the charge cycle which could take up to six hours per test. It would be desirable to achieve a total hands off operation where the battery goes through its total testing on a "non-stop" basis. But, this is basically not possible because of a variety of limitations. First of all, it is not possible to go from test to test without reviewing the results. All results, all cell readings that is, not just battery terminal voltage, must be evaluated (temperature included) to determine if the battery is ready for the next test. Depending on the readings it may be necessary to replace one or more cells and/or alter the test process. In addition, a battery that has just completed a capacity test or total discharge will be hot and therefore it has to be allowed to cool down prior to recharging it[7].

It is possible, however, to increase the efficiency of the charge/discharge process with equipment that can physically charge/discharge more than one battery at a time.

The Total Solution:

JFM Engineering offers the BTAS16 system for the automation of data in the battery shop as well as a variety of Precision Charger-Analyzers to test from main batteries to small packs, Nickel-Cadmium, Lead-Acid and other types of rechargeable batteries.

The main component of JFM's automation solution is the BTAS16. It is a system designed specifically for the automatic reading of battery voltages, cell voltages, charge/discharge currents and battery temperature, and for the presentation, analysis, reporting and archive of the information in a desktop computer.

The BTAS16 system can receive information from an array of up to sixteen data terminals (called C-Scan) and can in turn, provide limited monitoring and control of specially modified charger-analyzers such as the Superseder and 24-400T.

An assortment of battery specific crowns and universal leads with clips provide the electrical input to the C-Scans while auxiliary connections read the charge/discharge current, measure battery temperature (through a Temperature Plate) and monitor and control the Charger-Analyzers.

The end result is continuous measurements throughout the entire test cycle which presents to the operator a detailed view of the performance of the battery (and also of the Charger-Analyzer). In addition to basic tables of numeric results, the BTAS16 shows data in graphic format (voltage, current and temperature vs. time) with color coding in the bar graphs to highlight failing, marginal and acceptable results.

The advantage of the BTAS16 system is that, after each of the tests have been started, it becomes a hands-off operation by eliminating the need to watch over each of the batteries under test. With this system, all

[7] As stated earlier, a Nickel-Cadmium battery must not exhibit temperature rise during charge for it is a sign of cell separator failure, worn out cells, overcharge, etc. Therefore, if the battery is hot to begin with, it will not only mask-off internal problems, it will also prevent cells from reaching the proper charge voltage.

the technician needs to do is to periodically look at the colors in the graphs in search for any abnormalities, thus freeing the technician to perform other tasks in the battery shop.

A variety of reports provide also printed records of the tests performed suitable for record filing (audit trail) and presentation to the end user (work order summary).

Ultimately, all the data can be archived for review and comparison at any time.

For details on screens, reports and overall performance characteristics, see www.jfmeng.com (BTAS16)

The Charger-Analyzers offered by JFM Engineering are precision instruments designed to test batteries exactly as specified by the manufacturers of the batteries. In addition, they have ample protection to prevent damage to the batteries and to be intrinsically safe for the operator. www.jfmeng.com (Products)

The Superseder, in particular, is also designed for speedier operation for it is designed to handle more than one battery at a time (up to a total of 50 cells).

The Superseder can charge at maximum current up to 50 Nickel-Cadmium cells. This means that it can accommodate up to two 22 cell batteries, up to four 11 cell batteries and up to seven 7 cell batteries! In discharge it can also accommodate multiple batteries but at a reduced current if the total number of cells is over 22[8].

But, it is the combination of the Superseder Charger-Analyzer and the BTAS16 system that maximizes the efficiency of the operation, for it is not enough for the equipment to be capable of working on so many batteries at any one time if we still have to take manual readings!

The combination of the Superseder and 24-400T Charger-Analyzers and the BTAS16 provide a comfortable and effective hands-off operation. Once the system is setup and running, the technician can now dedicate time to other tasks in the battery shop, confident that at the end of the programmed tests all data will be recorded and ready for review.

[8] In case of multiple batteries, it must be remembered that the charger-analyzer only "understands" total number of cells. This means that multiple batteries are seen and are treated as one battery. Therefore, the capacity test of multiple batteries requires close monitoring of the individual battery voltages. The BTAS16 solves this problem by providing the required close monitoring, not only of the batteries as a whole but all cells individually as well.

JFM Engineering has been specializing in the development and manufacturing of precision instruments for the testing of batteries for the past 25 years.

In addition, JFM Engineering has an FAA certified repair station for the testing and maintenance of aircraft batteries of all types.

For additional information, please contact the sales department at 305-592-2272 (FAX 305-594-4933) or visit our website www.jfmeng.com for complete information on our products and services.