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SOME FACTORS TO CONSIDER IN DETERMINING THE CAPACITY OF A NICKEL CADMIUM CELL

BY
G. HALPERT

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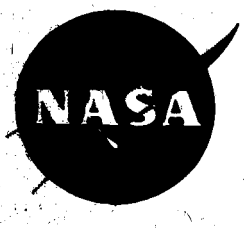

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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INTRODUCTION

It is widely recognized in the battery industry that the behavior of a sealed nickel cadmium cell is influenced by its past cycling experience. Both the need for "cell-conditioning" and the so called "memory phenomena" could be cited as examples of this effect. The treatment given a cell prior to a capacity test appears to be another example and is the basis for this report. A series of experiments are described in which two types of cells were discharged to 1.0 volt, then discharged further (drained or essentially short circuited) through a 1.0 ohm resistor for varying intervals prior to the capacity test. The experimental results indicate that there was a significant difference in capacity between those cells which were drained for more than 16 hours and those which were drained for short periods of 3 hours or not at all. The information derived from this study should be useful to individuals establishing battery test requirements or those who are users of nickel cadmium batteries.

TEST PROGRAM

This test was performed only to ascertain the effect of immediate prior history of a cell on the charging capacity of that cell. Other variables, such as temperature, rate of charge and discharge, time of charge and discharge, were established and maintained constant throughout the test.

The in-house test program comprised a series of capacity test cycles in which specimen cells were randomly stored in the drained and open circuit condition for relatively short periods (3-4 hours), moderate periods (16-24 hours), and long periods (72-96 hours) immediately prior to testing. The procedure established for determining capacity in this test program is as follows:

A. After discharge to 1.0 volt, continue the discharge through a 1.0 ohm resistor for a predetermined period.

B. Charge at *C/8 for 16 hours.

C. Open circuit stand 1 hour.

D. Discharge to 1.0 volt at C/2.

The randomized test schedule is given in the following table:

Step A	Test Number		
	Short Duration (3-4 hours)	Moderate Duration (16-24 hours)	Long Duration (72-96 hours)
Drain	16, 22, 31	21, 30	17, 26
Open Circuit	15, 20	18, 28	19, 29

The test number is the cycle in which the capacity was determined (capacity test cycle), and follows the treatment of Step A in the above procedure.

Ten nickel cadmium cells were utilized in this test. They included five of the well known 6-ampere-hour VO6-HS-AD aerospace cells with control electrode† and five similar cells with electrodes of a thin construction, designated VO6-HS-TP-AD. These cells were supplied by Gulton Industries under contract NAS 5-3839. They were given conditioning cycles plus a number of additional cycles so they could be described as being in the "active" condition. On test No. 14, the cells were given two consecutive 16 hour charges at C/8 followed by a normal discharge of 3 amperes to 1.0 volt. At this point the test program was initiated.

RESULTS

The capacity determination results shown in Figures 1 and 2 illustrate the effect of the immediate prior history on the capacity of the VO6-HS-AD and VO6-HS-TP-AD cells, respectively. The capacities were measured in the capacity test cycle following the open circuit or drain pre-treatment discussed earlier.

*C = rated capacity in a one-hour period. For purposes of this report, C = 6 in all cases.
†The control electrode was not used in this test.

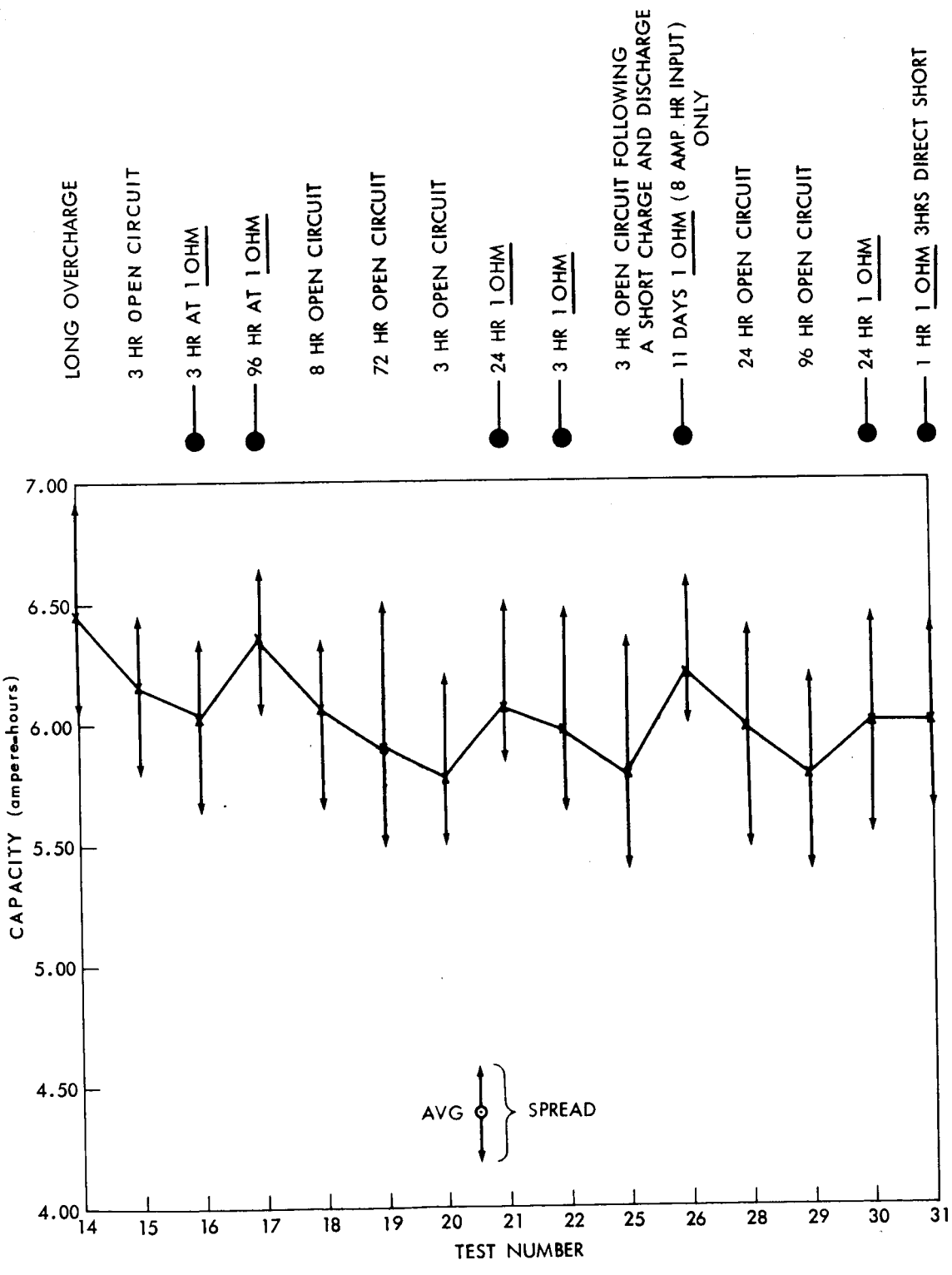

Figure 1–Effect of pre-treatment on the capacity of VO6-HS-AD cells.

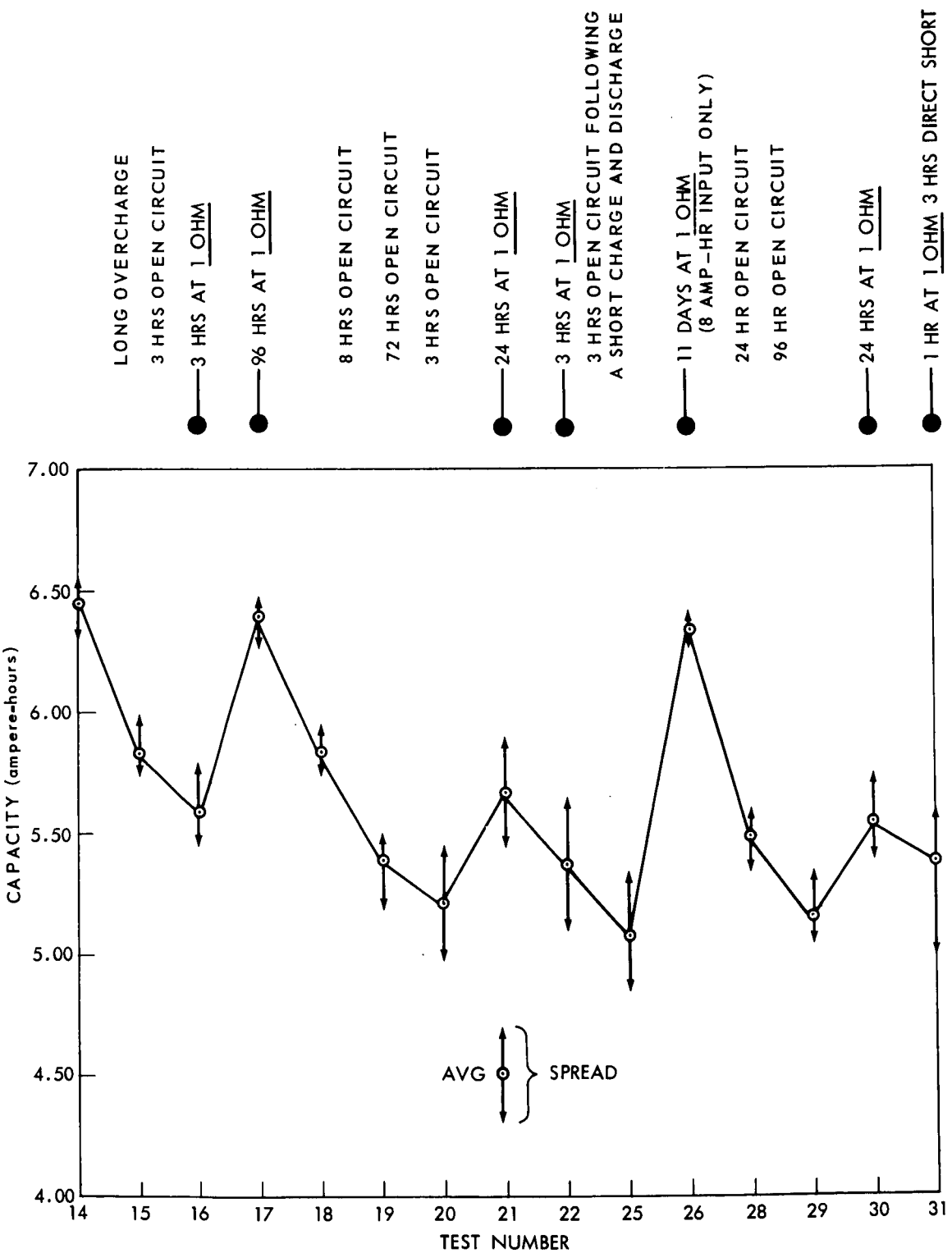

Figure 2–Effect of pre-treatment on the capacity of V06-HS-TP-AD cells.

The average maximum capacity of 6.45 ampere hours for both types of cell was noted in test No. 14, in which the cells were given a double charge. Only on Tests No. 17, 21, 26 and 30 did the capacity of the cells again approach this value. According to the previous Table, these tests followed a pre-treatment of a moderate or long drain through a 1.0 ohm resistor. It was also noted that the draining or open circuit pre-treatment for short periods did not improve the capacity. The extent to which the capacity was reduced by an open circuit pre-treatment was as much as 15%. An interesting side observation was that the thinner plate cells exhibited an exaggerated effect under the test conditions but followed the same results as the well known VO6-HS-AD cells. It was observed that a pre-treatment drain through a 1.0 ohm resistor for moderate or long periods caused the cells to exhibit the maximum capacity on the following cycle.

As the program progressed, some side effects became evident. On the charge following pre-treatment for a moderate or long period, the cells exhibited a different voltage characteristic from those left on open circuit. An example of cells on charge after drain (test No. 17) and after open circuit stand (test No. 19) appears in Figure 3. Two specific effects are apparent in the cells having had the long drain: (a) the maximum voltage attained is higher; and (b) the time to reach maximum voltage has increased. Data were accumulated for both of these characteristics and the results are shown in Figures 4 and 5. Figure 4 shows that the VO6-HS-AD cells were 10-15 mv higher on the average and the thinner plate VO6-HS-TP-AD cells were 50 mv higher on the average after a long drain pre-treatment. In test No. 28, an unexpected high voltage terminated charging of the VO6-HS-AD cells after 8 hours. Thus, the voltage shown for Test No. 28 is not actually the maximum. The time to reach the maximum voltage is plotted for all the tests in Figure 5. As was previously stated, a cell that is drained for moderate or long periods (Tests No. 17, 21, 26) takes longer to reach the maximum voltage on the following charge. The increase is approximately 2 hours at 0.75 amperes or 1.5 ampere hours.

The discharge voltage was also plotted for all tests. This voltage level was found not to be a function of the pre-treatment. However, as was previously mentioned, the discharge time down to 1.0 volt was affected, as can be seen in the capacity data.

CONCLUSION

These tests prove conclusively that the capacity of a sealed nickel cadmium cell is dependent on the treatment given it prior to the capacity

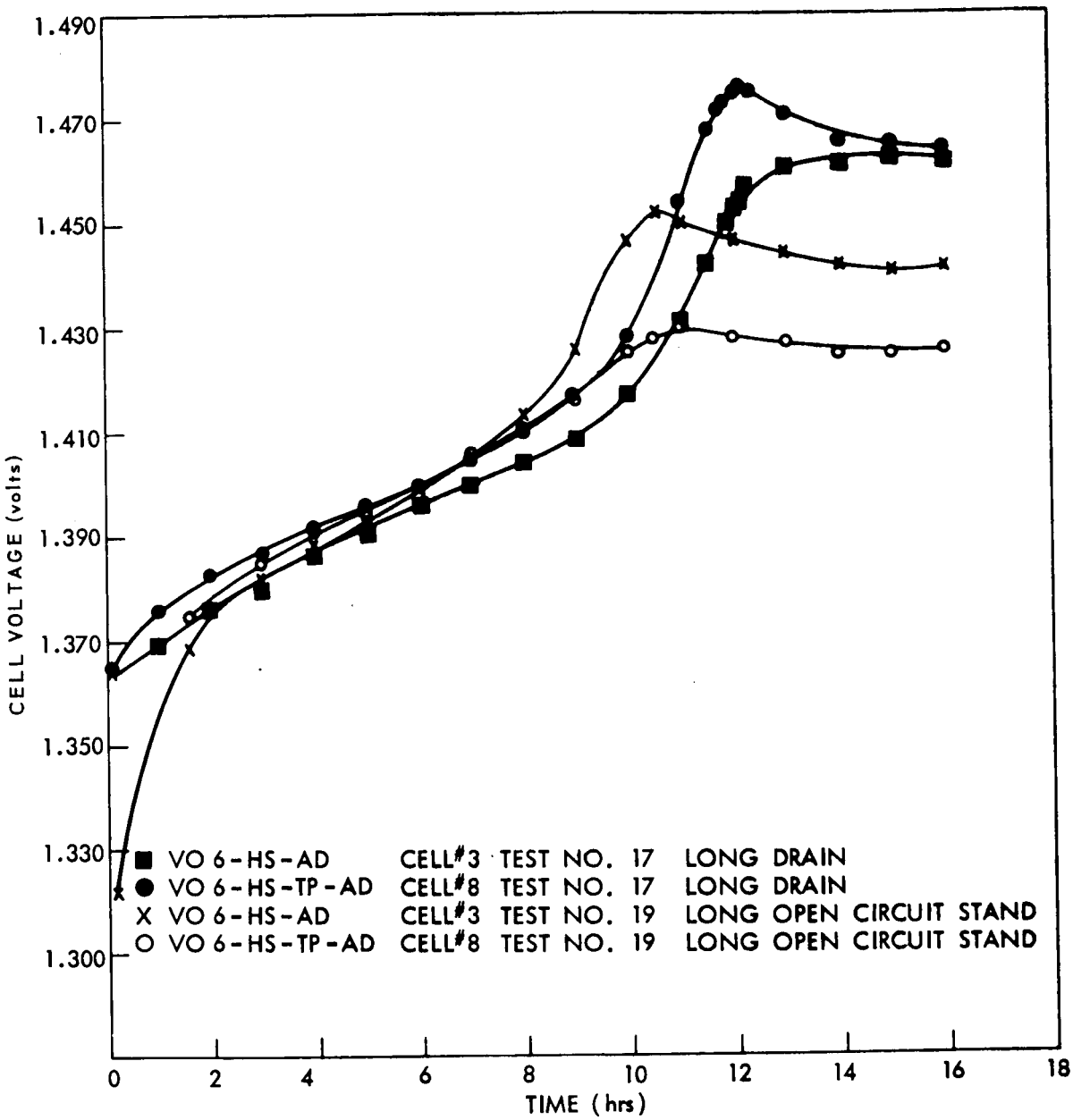

Figure 3–Effect of cell pre-treatment on cell voltage.

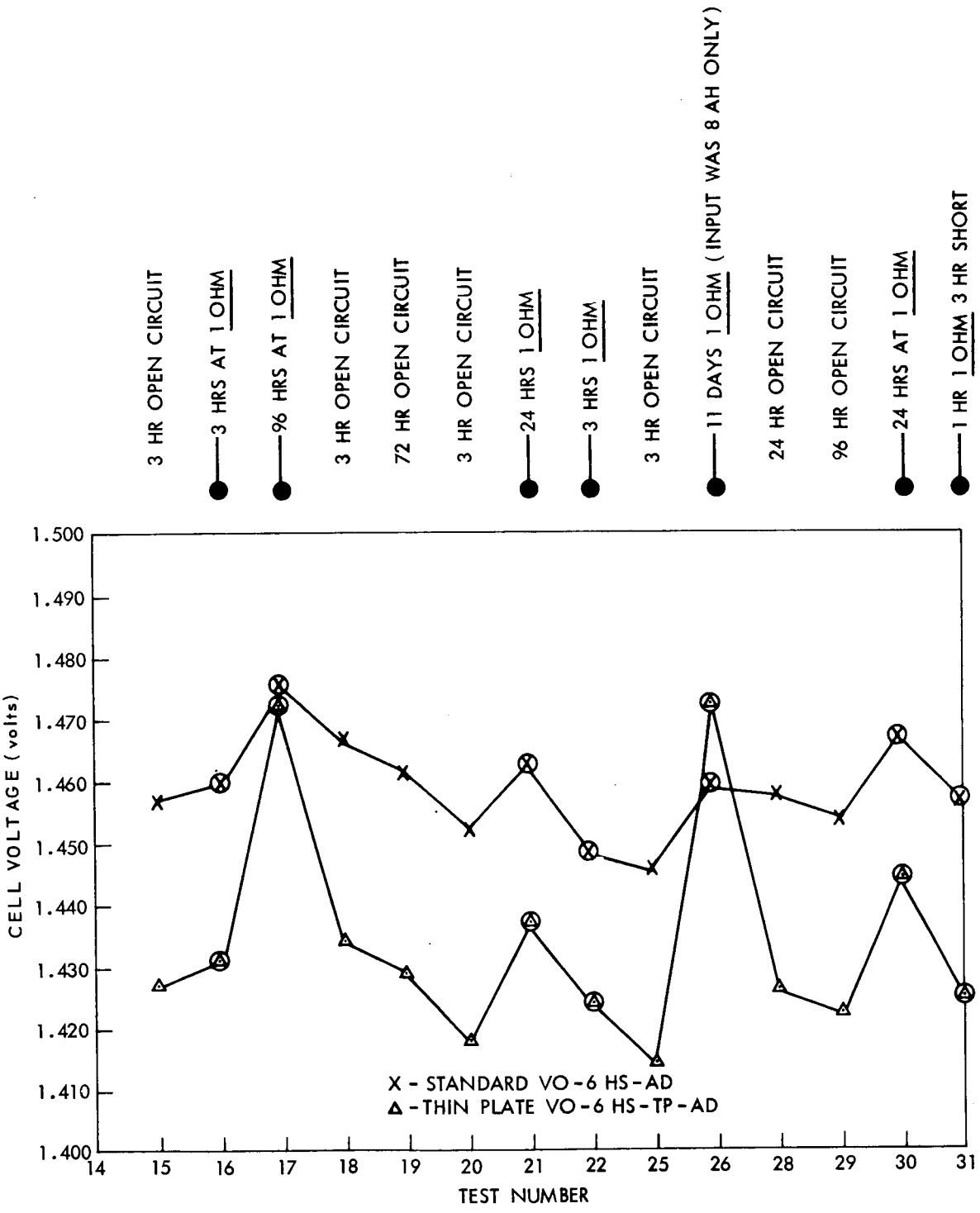

Figure 4–Effect of cell pre-treatment on peak cell voltage.

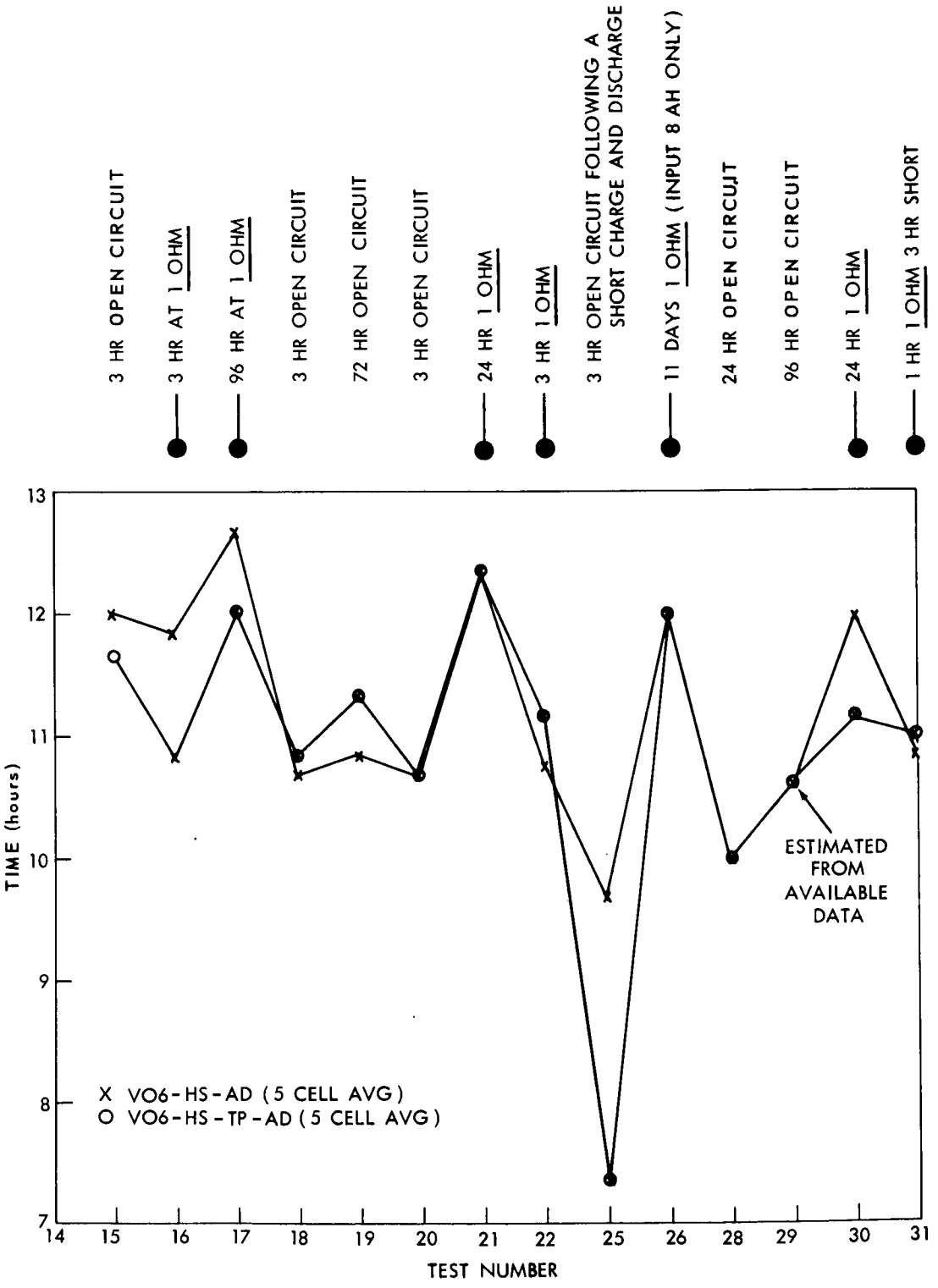

Figure 5–Effect of cell pre-treatment on the time to reach peak voltage.

test cycle. Specifically, the maximum capacity of such a cell is attained when it has been essentially short-circuited for a period of at least 16 hours prior to the test cycle. The results also indicate that when using the drain technique to achieve maximum capacity, the charge voltage maximum and the time to reach this maximum both increase.

During this test program no attempt was made to investigate other variables which might have an effect on these phenomena, such as temperature, rate of charge and/or discharge, etc. Similarly, no attempt has been made here to explain the observed cell behavior from a physical-chemical and electrochemical approach.

This report was written to aid those in the battery technology field in evaluating capacity data and charge voltage data from capacity tests on sealed nickel cadmium cells.