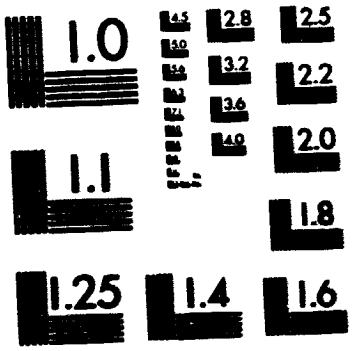

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ACCELERATED TEST PROGRAM

INTERIM REPORT

3 MAY 1979

PREPARED FOR

JET PROPULSION LABORATORY

National Aeronautics and Space Administration

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This report was prepared for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by NASA under contract NAS 7-100

DEPARTMENT OF THE NAVY
NAVAL WEAPONS SUPPORT CENTER
WEAPONS QUALITY ENGINEERING CENTER
CRANE, INDIANA 47522

ACCELERATED TEST PROGRAM FOR SEALED NICKEL-CADMIUM SPACECRAFT BATTERIES/CELLS INTERIM REPORT

WQEC/C 79-145

8 MAY 1979

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Enclosure (1)

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PREFACE

This Interim Report on the NASA Accelerated Testing of Space Cells is the summation of almost a decade of planning and work. Accelerated test requirements were first outlined in, "The Study of Space Battery Accelerated Testing Techniques", by Battelle Memorial Institute in September, 1969. (Reference 35). The basis and theory for the Accelerated Test were further discussed in, "Accelerated Testing of Space Batteries", in 1973, NASA SP-323. (Reference 23).

A working group consisting of representatives from NASA Headquarters, NASA Goddard, Wright Patterson Air Force Base and the Naval Weapons Support Center determined the test matrix, stress factors and stress levels used in the final test design. Other initial contributors to the program were Cryptanalytic Computer Sciences, Incorporated, Battelle Memorial Institute, and General Electric Company.

The results of the working group's effort are presented in Goddard Space Flight Center Report X-761-73-183, "Accelerated Test Plan for Nickel Cadmium Spacecraft Batteries". (Reference 7). Five stress factors were selected to evaluate accelerated testing. They were: 1) Depth of discharge, 2) Temperature, 3) Discharge rate, 4) Charge rate, 5) Overcharge. In addition to the stress factors, three cell design variables were evaluated: 1) Precharge, 2) Quantity of electrolyte, 3) Concentration of electrolyte.

When electrical test and failure data became available in 1976, a working group under the direction of NASA Goddard began the task of evaluating the test results. This group consisted of representatives from NASA Lewis NASA JPL, Wright Patterson Air Force Base and Naval Weapons Support Center. In January, 1978, program management was transferred from NASA Goddard to NASA JPL.

As of the writing of this report, all but six packs of 95 packs have completed test. Four of these packs are on "normal" test conditions, i.e., 0° and 20° C at 20% and 40% depth of discharge, 90 minute cycle, and some of these packs could cycle for an additional 8 years. Rather than wait until these last few packs fail, it was decided that an Interim Report should be published now to get the data summaries and the initial data analysis into public domain. Although the present report contains considerable data on failure analysis, little effort has been expended thus far in analyzing it. Considerable effort during the past year was made in computerizing the data files and assuring the data were correct. Additional effort was made in debugging computer programs and analyzing cycle life data for predictive techniques.

The Wright Patterson Air Force Base, AFAPL, contributed some of the funding for this program between 1975 and 1978, primarily for chemical and physical analysis.

Those people who have contributed to the performance of the program over the decade are as follows:

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SECTION I

INTRODUCTION

This Interim Report summarizes the results of the Accelerated Test Program for sealed nickel-cadmium spacecraft cells defined in NASA/GSFC Report X-761-73-183 (Reference 7). Testing was implemented in June 1974 and is approximately 90% complete.

The objectives of the Program were to develop 1) a tool for spacecraft projects and other battery users to determine the life capability of sealed, nickel-cadmium cells, 2) a method of evaluating the effect of design and component changes in cells and 3) a means of reducing the time and cost of cell testing. (Reference 7). These objectives as stated need further clarification. Objective 1, was to determine if "good" and "bad" cells could be differentiated under accelerated test conditions by testing only 1% to 5% of their cycle life. This would provide a screening test for selecting and matching the best cells of a lot for flight batteries.

Objective 2, was to determine if an accelerated test method could be developed to rapidly evaluate cell component design modifications by testing to failure using accelerated conditions rather than using real time test conditions.

Objective 3, is a natural fallout from 1 and 2 because the time to test will be shorter if cells can be tested at accelerated conditions and if the time on test is reduced, the cost of the test should be less.

It was recognized in the original plan that a useable accelerated test would depend on the fact that a smaller and simplier test program would evolve that would require significantly fewer cells. Therefore it is pointed out that the present accelerated test was not intended as a final accelerated test, but would provide the data base to model a small, practical accelerated test.

It was also recognized that an accelerated test must induce cell failure by the same degradation mechanisms as encountered in normal use. Since this could not be controlled, sample cells were chemically and physically analyzed from each group to determine the failure mechanism and relate this to true life. At present, analysis of the failure mechanisms have not been completed. The packs cycling under normal conditions have not failed, consequently, no failure analysis data is available for comparison with accelerated conditions. The program called for chemical and physical analysis on cells removed before failure, cells stored at various temperatures, uncycled cells and on all failed cells. The number of cells for analysis had to be reduced during the course of the program because the time required to complete the test would exceed the anticipated program completion date and the cost would exceed available funding. The cells have been stored and may be analyzed in the future, if desired.

SECTION II SUMMARY

A. TEST PLAN AND CYCLE RESULTS

This accelerated test was designed statistically using eight factors (five environmental and three physical previously identified as important to the battery performance) at five levels of stress for each factor. Using these parameters, a full factorial design on 5^8 would require 390,625 test "points." To keep the number of test points required to a minimum while obtaining the desired information on the eight factors and five levels of each factor, a composite design concept was used. This design consists of three statistical elements identified by the terms, fractional factorial, star points and center point. Table II-1 summarizes the eight factors and associated levels in the accelerated test program. The fractional factorial (1/4 of 2^8 fractional) evaluates the eight test parameters at a high and low level (levels 2 and 4 of Table II-1) to determine which main effects and two-way interactions that have a significant effect on cell life. The star points of the design take each extreme level (levels 1 and 5 of Table IV-1) of each factor in combination with the center level (level 3 of Table IV-1) of the remaining seven factors. The center point of the design is determined by the eight factors of the center level (level 3 of Table IV-1). This part of the composite design gives a method of evaluating the non-linear effect of the factors without a sizeable increase in the number of packs required. The fractional factorial required 64 samples; the star points required 16 samples; and the center point required one sample. A second sample was tested at the center point levels. This sample was to be used to estimate the pack-to-pack variation in the test. In addition 4 samples were put on test at "normal" test condition to evaluate the actual performance under normal conditions.

Samples (packs) used herein consisted of five cells in series with each cell mounted between one-quarter inch thick metal retainer plates for heat transfer and separated from its neighboring cell by a 1-inch air space. The cells designated as positions 1 and 2 of the fractional factorial and positions 1, 2 and 3 of the star points, center points and normal points were equipped with a pressure transducer. The star points, center point and normal point packs contain eight cells as the additional three cells were to be removed from test for chemical and physical analysis at one-fourth, one-half, and three-fourths of expected cycle life. A total of 87 packs were put on cycle test. A third center point pack was put on test because one of the packs failed prematurely due to equipment malfunction.

TABLE II - 1 TEST MATRIX PACK SUMMARY - TEST FACTORS AND LEVEL

ENVIRONMENTAL FACTORS	LEVELS				
	1 LOW STAR POINT	2 LOW FACTO-RIAL	3 CENTER POINT	4 HIGH FACTO-RIAL	5 HIGH STAR POINT
1. Temperature °C (T)	20	30	40	50	60
2. Depth of Discharge %(DOD)	20	40	60	80	100
3. Charge Rate (CR)	C/4	C/2	C	2C	4C
4. Discharge Rate (DR)	C/2	C	2C	4C	8C
5. Percent Recharged (%RC)	110	140	140	200	200
DESIGN FACTORS					
6. Concentration of Electrolyte (%KOH)	22	26	30	34	38
7. Amount of Electrolyte (CC)	17.5	18.5	19.5	20.5	21.5
8. Ampere-Hours of Precharge (AH)	2.20	2.50	2.80	3.00	3.30

(1) Each star point pack was tested at either the very high or very low level of a designated test parameter. The levels of the other test parameters were held at the center level. For example, the star point pack tested at 20° C was tested with the levels of DOD = 60%, CR = C, DR = 2C, Recharge = 140%, %KOH = 30%, Quantity KOH = 19.5cc, and Precharge = 2.8Ah, which are the center point levels.

(2) The two center point packs were tested at the center levels of the test parameters as listed in the Table.

(3) The 64 factorial points were tested at combinations of the low and high levels of each test parameter. This is further illustrated in Figure IV-1.

The eight factors used for this program were: 1) temperature, 2) depth of discharge, 3) charge rate, 4) discharge rate, 5) percent recharged, 6) concentration of electrolyte, 7) amount of electrolyte and 8) ampere-hours of precharge. It is noted that the last three factors are cell design variables. The factors were used to evaluate the effects of cell design on the performance.

The test samples were nominal six ampere hour sealed nickel cadmium cells manufactured by the General Electric Company from three lots of plate material between June, 1973 and June, 1975. The cells were manufactured to GSFC specification except as modified to include the three design variations as listed in Table II-1. The cells contained non-teflonated negative electrodes and were not silver treated. The decarbonization process was not used on these cells. The positive electrode contained 1.38 grams of cadmium hydrate per plate.

The cells were subjected to the manufacturers electric tests per GE specification P24A-PB-150. After receipt at NWSC, the cells were inspected, assembled into packs and subjected to the baseline tests detailed in Appendix A.

A cell was considered to have failed when the discharge voltage dropped to 0.0 volts before the end of the discharge period, or when the pressure reached 250 psia on cells containing pressure transducers. It was initially planned to remove all cells from test when the last cell in the pack containing a pressure transducer reached 250 psia. During the course of the program, the plan was modified to record the cycle when a cell reached 250 psia, and continued to cycle the cell until it failed by low voltage or shorted.

In addition to the electrical test matrix described above, cells were also procured for supplementary tests that would be correlatable with the composite design and benefit the overall program. These tests were chemical and physical analysis of 1) virgin (uncycled) cells; 2) cell removed from test at one-fourth, one-half, and three-fourths life; 3) cells stored in a controlled temperature environment; 4) all failed cells. A total of 546 cells were purchased for the program.

The packs were life cycled utilizing the automatic data acquisition and control system described in Appendix B. The system recorded data on every cycle at 36 second intervals on each pack during the early part of life (first 500 cycles); thereafter, only the beginning and end points of each charge and discharge cycle were recorded for the remainder of life. In December, 1977, the data recording was changed to record three full cycles at 50 cycle intervals on fractional factorial packs and at 100 cycle intervals on normal condition packs. Cycling tests began with the star points, center point and normal point packs in September 1974. The fractional factorial packs were added from December 1974 to January 1977. As with any large test program, equipment failures, system malfunctions and human errors occurred causing test anomalies which in some cases induced cell failures. A summary of pack test anomalies is given in Appendix C.

As of January, 1979, 81 of 87 packs have completed life cycling tests. One fractional factorial point (Pack 5N) and one center point (Pack 96N) are still cycling with three and two failures respectively. All 4 normal test conditions)Packs 83N, 84N, 85N, and 86N) are still cycling with one failure each in packs 83N and 86N. Post cycling tests were completed on all packs that have completed life cycling. Two packs, 93N and 94N, containing three and two cells respectively, remain stored in the controlled temperature environments of 0° C and 20° C. These cells will be removed from the environment and chemically analyzed for comparison with cells in packs 85N and 84N respectively. The cycle test results to 0.0 V failure are summarized in Table II-2.

TABLE II-2 ACCELERATED TEST LIFE-CYCLING INFORMATION

Fractional Factorial													Cell Failure on Test (Cycles)									
													Cell Numbers and Mode* for Removal									
Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles (Failure)	1	*M	2	*M	3	*M	4	*M	5	*M
1N	30	40	C	0.40	1.12	C/2	140	26	18.5	2.50	5	12745	8144	S	7090 9148	P L	10914	L	10791	L	12745	S
2N	50	80	C	0.80	0.56	2C	140	34	20.5	3.00	5	964	964	S	948	L	840	L	947	L	945	L
3N	30	80	4C	0.20	0.80	2C	200	26	18.5	3.00	5	1791	1600	L	474	H	1609	L	1791	L	1536	L
4N	50	40	4C	0.10	1.60	C/2	200	34	20.5	2.50	5	3532	3532	S	3318	L	3092	S	3014	L	3374	S
5N	30	40	C	0.40	1.60	C/2	200	34	20.5	3.00	5	12197**			1446	P	9942	L***			10034	L***
6N	50	80	C	0.80	0.80	2C	200	26	18.5	2.50	5	810	601	L	485	H	810	L	747	L	704	L
7N	30	80	4C	0.20	0.56	2C	140	34	20.5	2.50	5	3298	3136	L	2915	PL	3034	L	2650	L	3298	L
8N	50	40	4C	0.10	1.12	C/2	140	26	18.5	3.00	5	4661	3795	L	2563	L	4192	L	4099	L	4661	S
9N	30	40	4C	0.10	0.28	2C	140	26	20.5	3.00	5	17403	10211	P	11097 15513	P L	17135	H	12145	H	17403	H
10N	50	80	4C	0.20	2.24	C/2	140	34	18.5	2.50	5	20	11	L	13	L	20	L	19	L	20	L
11N	30	80	C	0.80	3.20	C/2	200	26	20.5	2.50	5	2582	1575	H	1568	H	2582	S	2003	S	2402	S
12N	50	40	C	0.40	0.40	2C	200	34	18.5	3.00	5	2054	910	H	920	H	2034	L	2051	L	2054	L
13N	30	40	4C	0.10	0.40	2C	200	34	18.5	2.50	5	12179	5236 8020	P H	4258	S	2695	S	10818	S	12179	H
14N	50	80	4C	0.20	3.20	C/2	200	26	20.5	3.00	5	34	27	L	26	L	34	L	32	L	33	L
15N	30	80	C	0.80	2.24	C/2	140	34	18.5	3.00	5	3242	895	P	3242	L	1717	H	2700	L	1717	H
16N	50	40	C	0.40	0.28	2C	140	26	20.5	2.50	5	6253	1003	H	4202	L	5691	S	6253	L	5652	S

* Explanation for Mode for Removal

P - Pressure greater than 250 psia
L - Low cell voltage
A - Cell removed, when all cells of the pack having a pressure transducer failed, as a safety precaution
S - Cell shorted - would not accept charge
R - Cells removed before failure as specified
PL - Pressure greater than 250 psia - Low cell voltage
H - Hardware malfunction

**Pack still cycling
***Unverified failures

TABLE II-2 (continued)

Fractional Factorial — Cell Failure on Test (Cycles)

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles (Failure)	Cell Numbers and Mode* for Removal 1	*M	2	*M	3	*M	4	*M	5	*M
17N	50	80	C	0.80	0.56	2C	140	26	18.5	3.00	5	1351	1085	P	1351	L	1333	L	1265	L	1329	S
18N	30	40	C	0.40	1.12	C/2	140	34	20.5	2.50	5	12467	7301	L	12467	L	10483	L	5221	L	6707	L
19N	50	40	4C	0.10	1.60	C/2	200	26	18.5	2.50	5	2830	2760	L	1734	S	2809	H	2342	S	2830	H
20N	30	40	4C	0.10	0.28	2C	140	34	20.5	3.00	5	14366	2939 6178	P S	621	P	14366	S	10513	S	12334	S
21N	50	80	C	0.80	0.80	2C	200	34	20.5	2.50	5	489	425	S	102	P	449	S	489	S	420	S
22N	30	40	C	0.40	1.60	C/2	200	26	18.5	3.00	5	4891	4891	L	2722	L	2176	L	3285	L	2178	L
23N	50	40	4C	0.10	1.12	C/2	140	34	20.5	3.00	5	4650	553	L	480	L	4609	L	4650	L	4583	S
24N	50	80	4C	0.20	0.56	2C	140	26	18.5	2.50	5	2041	1577 2041	P L	1486	P	1944	L	1895	L	1868	L
25N	50	80	4C	0.20	2.24	C/2	140	26	20.5	2.50	5	40	36	L	20	L	37	L	37	L	40	L
26N	30	40	4C	0.10	2.28	2C	140	34	18.5	3.00	5	12151	3745	L	12151	S	11067	L	11064	L	12096	S
27N	50	40	C	0.40	0.40	2C	200	26	20.5	3.00	5	2715	2251 2715	P L	2254	H	2537	L	2694	S	2708	S
28N	30	80	C	0.80	3.20	C/2	200	34	18.5	2.50	5	2561	2033	L	2561	L	2251	H	2369	S	2155	S
29N	50	80	4C	0.20	3.20	C/2	200	34	18.5	3.00	5	25	23	L	23	L	23	L	24	L	25	L
30N	30	40	4C	0.10	0.40	2C	200	26	20.5	2.50	5	7459	4324 5599	P L	3569	L	5755	S	5620	S	7459	L
31N	50	40	C	0.40	0.28	2C	140	34	18.5	2.50	5	4755	3239	L	4690	L	4613	S	4449	S	4755	L
32N	30	80	C	0.80	2.24	C/2	140	26	20.5	3.00	5	3166	640	H	2931 3166	P S	2952	L	2933	H	2398	L

TABLE II-2 (continued)

Fractional Factorial

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles (Failure)	Cell Failure on Test (Cycles) Cell Numbers and Mode* for Removal 1	*M	2	*M	3	*M	4	*M	5	*M
33N	30	80	4C	0.20	3.20	C/2	200	34	20.5	2.50	5	2327	1829 1913	P L	1771	P	2075	L	2207	L	2327	L
34N	50	40	4C	0.10	0.40	-	200	26	18.5	3.00	5	3395	2712	P	3052 3206	P S	3158	S	2966	S	3395	S
35N	30	40	C	0.40	0.28	2C	140	34	20.5	3.00	5	5907	258	P	111	P	4077	L	4044	S	5907	L
36N	30	80	C	0.80	2.24	C/2	140	26	18.5	2.50	5	1398	1369	L	1398	L	1360	L	1247	L	1241	L
37N	30	80	4C	0.20	2.24	C/2	140	26	18.5	3.00	5	1454	1454	L	1293	L	1187	L	1213	L	1296	L
38N	50	40	4C	0.10	0.28	2C	140	34	20.5	2.50	5	7422	7422	L	5650	P	6172	L	6937	L	6404	L
39N	30	40	C	0.40	0.40	2C	200	26	18.5	2.50	5	9640	4955	L	8608	S	9640	L	5227	S	7102	L
40N	50	80	C	0.80	3.20	C/2	200	34	20.5	3.00	5	733	443	H	733	L	541	L	587	L	438	L
41N	30	80	C	0.80	0.80	2C	200	34	18.5	3.00	5	816	727	S	816	L	809	L	401	L	576	L
42N	50	40	C	0.40	1.60	C/2	200	26	20.5	2.50	5	966	832	L	523	P	682	S	958	L	966	L
43N	30	40	4C	0.10	1.12	C/2	140	34	18.5	2.50	5	10677	10221	L	6750	L	10677	L	9572	L	10081	L
44N	50	80	4C	0.20	0.56	2C	140	26	20.5	3.00	5	2609	1675 2302	P L	1591	P	2369	L	2537	L	2609	L
45N	30	80	C	0.80	0.56	2C	140	26	20.5	2.50	5	1960	483	P	1960	L	537	L	1610	S	1525	L
46N	50	40	C	0.40	1.12	C/2	140	34	18.5	3.00	5	3205	3205	L	3015	L	2966	L	3173	L	3192	L
47N	30	40	4C	0.10	1.60	C/2	200	26	20.5	3.00	5	8018	7589 8018	P L	7290 7776	P L	7513	L	7776	L	6603	L
48N	50	80	4C	0.20	0.80	2C	200	34	18.5	2.50	5	827	827	S	570	P	754	S	792	S	813	S

TABLE II-2 (continued)

Fractional Factorial

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles (Failure)	Cell Failure on Test (Cycles) Cell Numbers and Mode* for Removal 1	*M	2	*M	3	*M	4	*M	5	*M
49N	50	40	4C	0.10	0.40	2C	200	34	20.5	3.00	5	3946	3466 3946	P L	1647	P	3764	L	3057	S	3939	L
50N	30	80	4C	0.20	3.20	C/2	200	26	18.5	2.50	5	1726	1663 1695	P L	1577	L	1726	L	1698	L	1726	H
51N	50	80	C	0.80	2.24	C/2	140	34	20.5	2.50	5	12	10	H	12	H	11	H	10	H	10	H
52N	30	40	C	0.40	0.28	2C	140	26	18.5	3.00	5	9960	4976	L	3327	S	9905	L	9960	L	9291	S
53N	50	40	4C	0.10	0.28	2C	140	26	18.5	2.50	5	6676	6093	P	6676	L	6676	H	5471	L	4813	L
54N	30	80	4C	0.20	2.24	C/2	140	34	20.5	3.00	5	1954	1789	L	1954	L	1153	L	1940	L	1348	L
55N	50	80	C	0.80	3.20	C/2	200	26	18.5	3.00	5	433	325	H	282	H	433	H	431	H	429	L
56N	30	40	C	0.40	0.40	2C	200	34	20.5	2.50	5	7272	3873	L	3832	L	5892	S	7272	S	3760	S
57N	50	40	C	0.40	1.60	C/2	200	34	18.5	2.50	5	2896	2888	L	2528	L	2611	S	2451	S	2896	S
58N	30	80	C	0.80	0.80	2C	200	26	20.5	3.00	5	1734	1524	L	1733	S	1684	L	1676	L	1734	L
59N	50	80	4C	0.20	0.56	2C	140	34	18.5	3.00	5	1613	1442 1605	P S	1146	P	1416	S	1613	S	1590	L
60N	30	40	4C	0.10	1.12	C/2	140	26	20.5	2.50	5	8768	8631 8768	P L	6472	P	8614	L	8167	L	8458	L
61N	50	40	C	0.40	1.12	C/2	140	26	20.5	3.00	5	2518	2518	S	2344	L	2302	S	2115	L	2466	L
62N	30	80	C	0.80	0.56	2C	140	34	18.5	2.50	5	3029	1610	S	1907	L	2555	L	2933	L	3029	L
63N	50	80	4C	0.20	0.80	2C	200	26	20.5	2.50	5	1075	411	P	793 1032	P L	1075	L	945	L	1060	L
64N	30	40	4C	0.10	1.60	C/2	200	34	18.5	3.00	5	6917	6917	PL	6136 6269	P L	5850	L	6660	L	6071	L

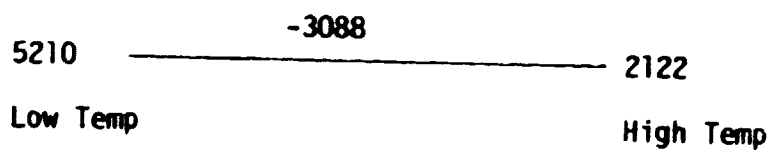
TABLE II-2 (Continued)

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	TOTAL CYCLES (Failure)	Cell Failure on Test (Cycles) — Cell Number and Mode* for Removal: 1	*M	2	*M	3	*M	4	*M	5	*M	6	*M	7	*M	8	*M
Star Points																												
65N	20	60	2C	0.30	0.84	C	140	30	19.5	2.80	8	5660	3157	H	5660	L	3157	H	4165	L	4465	L	2953	R	1504	R	771	R
66N	60	60	2C	0.30	0.84	C	140	30	19.5	2.80	8	13	13	L	13	L	13	L	13	L	13	L	13	L	13	L	13	L
67N	40	20	2C	0.10	0.28	C	140	30	19.5	2.80	8	14066	8242	H	9313	H	9313	H	14066	L	13662	S	6867	R	4500	R	2252	R
68N	40	100	2C	0.50	1.40	C	140	30	19.5	2.80	8	955	523	P L	471	P L	523	P L	951	L	955	H	300	R	202	R	100	R
69N	40	60	2C	0.30	3.36	C/4	140	30	19.5	2.80	8	592	592	H	183	L	171	L	127	L	130	L	140	L	171	L	502	R
70N	40	60	2C	0.30	0.21	4C	140	30	19.5	2.80	8	1512	683	P	758	P	653	P	1512	A	1512	A	1201	R	856	R	401	R
71N	40	60	C/2	1.20	0.84	C	140	30	19.5	2.80	8	1638	1625	P	1638	H	1185	P	1422	R	1414	L	1355	L	1518	L	752	R
72N	40	60	8C	0.075	0.84	C	140	30	19.5	2.80	8	1717	1304	P	1646	P	1352	H	1717	A	1717	A	149	R	101	R	50	R
73N	40	60	2C	0.30	0.660	C	110	30	19.5	2.80	8	3501	1938 2203	P L	3501	H	3494	P	3501	A	3501	A	867	R	624	R	375	R
74N	40	60	2C	0.30	1.20	C	200	30	19.5	2.80	8	1810	1196	P	1195	P	1648	P	1803	S	1810	S	375	R	250	R	141	R
75N	40	60	2C	0.30	0.84	C	140	22	19.5	2.80	8	2557	2447	P	1818	P	1490	P	2557	L	2486	L	2250	R	1505	R	750	R
76N	40	60	2C	0.30	0.84	C	140	38	19.5	2.80	8	1669	1201	P	1667	P	1115	L	1669	A	1669	A	876	R	623	R	337	R
77N	40	60	2C	0.30	0.84	C	140	30	19.5	2.20	8	1909	1909	H	1870	P	1909	H	1909	H	1909	H	1504	R	1111	R	615	R
78N	40	60	2C	0.30	0.84	C	140	30	19.5	3.30	8	2368	2245	P	2359	L	2347	L	2354	S	2368	S	748	R	509	R	251	R
79N	40	60	2C	0.30	0.84	C	140	30	17.5	2.80	8	3679	2158	P	3310	S	1480	P	3679	S	3732	A	1463	R	1112	R	580	R
80N	40	60	2C	0.30	0.84	C	140	30	21.5	2.80	8	3223	3223	P	2297	L	2328	P	2319	S	2467	S	1425	R	953	R	511	R
Center Points																												
81N	40	60	2C	0.30	0.84	C	140	30	19.5	2.80	8	3055	3014	L	1579	P	1039	P	3055	A	3055	A	1510	R	1001	R	502	R
82N	40	60	2C	0.30	0.84	C	140	30	19.5	2.80	5	3803	678	H	678	H	3803	L	678	H	678	H						
96N	40	60	2C	0.30	0.84	C	140	30	19.5	2.80	4	6153**	*** 4153	L	*** 2678	S	*** 2704	L										
Normal Conditions																												
83N	0	40	C/1.20	0.48	1.00	C/2.38	105	34	18.5	2.50	8	21186**			7768	L							12758	R	8533	R	4255	R
84N	20	20	C/2.40	0.48	1.00	C/4.76	105	34	18.5	2.50	8	20433**											20255	R	13674	R	6836	R
85N	0	20	C/2.40	0.48	1.00	C/4.76	105	34	18.5	2.50	8	21541**															12054	R
86N	20	40	C/1.20	0.48	1.00	C/2.38	105	34	18.5	2.50	8	20605**			*** 19547	L							9799	R	6508	R	3262	R

The "Composite Design" test matrix was a statistically designed experiment to obtain balanced data on all of the eight test parameters so that standard statistical techniques could be applied in analyzing the data. The basic plan was: perform analysis of variance (ANOVA) to determine the significant test parameters and interactions; using ANOVA results perform linear regression with the significant factors as independent variables; analyze equations obtained from the regression; identify possible individual cell characteristics and apply regression techniques.

B. ANALYSIS OF VARIANCE (ANOVA)

Analysis of variance is a statistical procedure used to test the results of a properly designed experiment to determine if the differences observed in the results are due to the effects of test parameters or to random variation of the test samples. In this analysis main effects and two-way interactions were tested. A significant main effect means that the measured response is different for different values of that parameter. This is illustrated by the following diagram which contains the mean cycle life (Cycles to 0.0 Volts) of cells tested at the high temperature conditions (50° C) and the cells tested at the low temperature conditions (30° C).



There was a difference of 3088 cycles between cells cycled at the low and high temperature conditions. The ANOVA is a technique to determine whether or not this can reasonably be attributed to random fluctuations in the test. In this case the difference was not due to random fluctuations. Other variables are summarized in Section VI, Table VI-5. A two-way interaction between two parameters exists when the effect of one parameter is different for different levels of the second parameter. This is illustrated as follows:

TWO-WAY INTERACTION T AND CR

		T	
		High (50° C)	Low (30° C)
CR	High	2713	5044
	Low	1532	5374

The diagram shows that there is an interaction between temperature (T) and Charge Rate (CR). At the high temperature the cycle life is reduced by 1181 cycles when changing from the high CR to the low CR. At the low temperature the CR has an opposite effect, an increase of 330 cycles. It is also seen that going from temperature to temperature produces the greatest effect. The results of the two-way interactions for all eight test variables are given in Section VI, Table VI-6. Data is presented using four different failure criteria; cycles to 0.0V and 1.0V, cycle life time (hours) to 0.0V and 1.0V.

Several analysis of variances were performed using the fractional factorial data of the test design to select the "best" composite set of significant factors that determines the life of the cells. Four failure definitions, response variables, were used: cycles to 0.0 volts, hours to 0.0 volts, cycles to 1.0 volts, and hours to 1.0 volts. The "best" composite set of significant factors for each failure criteria is shown in Table II-3. In determining the composite set a factor that was significant as an interaction was also included as a main effect. This was the case for the variables precharge ampere-hours and concentration of electrolyte.

TABLE II-3 "BEST" COMPOSITE SET OF SIGNIFICANT FACTORS

CYCLES TO 0.0 Volts	HOURS TO 0.0 Volts	CYCLES TO 1.0 Volts	HOURS TO 1.0 Volts
T	T	T	T
DOD	DOD	DOD	DOD
CR	CR	CR	CR
DR	DR	DR	DR
CHG	CHG	CHG	CHG
	PKOH	PKOH	PKOH
PC	PC	PC	PC
T X DOD	T X DOD	T X DOD	T X DOD
T X CR	T X CR		T X CR
			T X DR
		T X PKOH	
DOD X CR	DOD X CR	DOD X CR	
DOD X DR	DOD X DR		
DOD X CHG			
CR X DR	CR X DR	CR X DR	CR X DR
	CR X CHG		
DR X CHG		DR X CHG	DR X CHG
		DR X PC	DR X PC
CHG X PC	CHG X PC		

In order to obtain a better understanding of the significance of a factor or interaction one needs to study the mean failure time tables VI-5 and VI-6 in Section VI. This has not been done in this report. An additional report will analysis these tables.

C. STEPWISE MULTIPLE LINEAR REGRESSION

After performing the ANOVA, a stepwise multiple-linear regression (SMLR) was performed to obtain an equation that best fits the response surface of the test results. The resultant equation is of the form:

$$y = b_0+b_1x_1+b_2x_2+\ldots+b_ix_i+\ldots b_nx_n$$

where y = Life
x_i = significant main effect or interaction
b_i = coefficient of the corresponding main effect or interaction.

The regression was also performed using the natural logarithm of life.

Those factors (test variables) that were determined to be significant from the ANOVA were allowed to enter the SMLR equation and coefficients of the corresponding main effect or interaction term were determined. Four equations were generated; one for each of the four failure definitions. The data from both the star points, center point and the factorial packs was used in generating the equation and the coefficients. The equations are shown in Table VI-7 of Section VI. The test parameters of each pack were then substituted into the equations and a prediction for the average cell life was obtained. These predictions are given in Table VI-9 of Section VI.

To illustrate,

The following equation was generated to predict (within the range of the accelerated test parameters) cycle life to 0.0 volts. To do so, substitute the test parameters and perform the arithmetic:

$$\begin{aligned}\text{Cycle Life (To 0.0 Volts)} = {} & 46231 - 3.91(T \times DOD) + 10.09(CR \times DR) \\ & + .96(DOD \times CHG) - 427.31(T) \\ & - 801.33(DOD) + 3.31(DOD \times DOD) \\ & - 63.5(CHG) - 7.19(CR \times CR) \\ & - 2.03(DOD \times DR) + 328.31(DR) \\ & - 2.68(DR \times DR) - .89(CHG \times DR) \\ & + 6.58(T \times CR) - 229.67(CR)\end{aligned}$$

NOTE UNITS are T = °C, DOD = %, CR and DR = Amps, and CHG = %.

As was previously stated, the coefficients and equations that were generated by the regression analysis are valid only in the range of the test parameters; i.e. only within the range of the five levels of stress of this test plan. Extrapolation of the equation outside of the range must be done with care, because there is no guarantee the equation will be valid. The test plan has cells cycling at normal conditions, thus data is available for comparison of actual life with predicted life from these extrapolated equations. This was done.

The extrapolation properities of this equation to normal test conditions does not appear to be exceptionally good. The prediction standard deviation could be as high as 40% of the predicted values. The prediction of five of the equations are summarized in Table II-4.

TABLE II-4

PREDICTED VALUES FOR NORMAL TEST PACKS FROM REGRESSION EQUATION

			Failure Criteria				
Pack No.	DOD %	Temp. °C	Cycles To 0.0V	Hours To 0.0V	Cycles To 1.0V	Hours To 1.0V	Ln cycles To 0.0V
83N	40	0	17029	23265	11666	29424	50559
84N	20	20	20256	21541	16226	22716	42024
85N	20	0	27073	31298	20863	38123	72793
86N	40	20	11942	15183	8423	15755	21978

The predictions in the first four columns all appear low; however, the predictions in the last column where the natural logarithm of life was used appears to give results that may be close to the actual life. All of the normal packs have passed 21,000 cycles, but pack 86N has had two failures near 20,000 cycles so the position appears close. Also in looking at other cells on test at Naval Weapons Support Center, Crane, the predictions of the other packs appear reasonable.

It is also noted that the predictions for the normal cells are in the correct order for the % DOD and temperature conditions. Further work in input data selection and analysis is needed to guarantee the best regression prediction equations. The results are encouraging and indicate accelerated testing is feasible.

D. NONLINEAR MODELS

Various members of the working group have suggested non-linear equations because some of the test parameters were better described by an exponential function. The four equations suggested were:

1) Cycle Life = a(b-TEMP) exp (cDOD)

2) $$\text{Cycle Life} = \frac{a\left[\frac{123-DOD}{DOD}\right]^{b}\exp\,(cTEMP)}{(\%\ RECHARGE)^{d}}$$

3) Cycle Life = $a(bDOD+c(TEMP+273)^{-1})$

4) $$\text{Life (Hours)} = \frac{a(1-\exp(b(TEMP-c)))\exp(dDOD)}{(\%\ RECHARGE)^{e}}$$

The coefficients for the equations were determined and predictions for the normal packs calculated. The predictions are listed in Table II-5.

TABLE II-5

PREDICTED CYCLE LIFE OF NORMAL PACKS BY THE NON-LINEAR EQUATION'S

Pack No.	DOD %	Temp OC	Equation Number and Prediction			
			1	2	3	4
83	40	0	17469	43813	31726	16979
84	20	20	25910	49432	26569	15861
85	20	0	36989	103267	67839	22919
86	40	20	12239	20004	12425	11750

NOTE: Equations 1, 2, 3, predict cycle life to 0.0V.
Equation 4 predicts cycle hours to 0.0V.

Observing the results it appears equations 1, 3 and 4 are predicting low results. Equation 2 appears to be predicting good results except for pack 85 which appears to be too high. These were first attempts to model life predictions and additional effort is needed to refine the models. It is interesting to note that these models use only two to three of the test factors. Including some of the other test factors and modifying the equation's is expected to improve their prediction capabilities.

E. TiBAR PREDICTIVE TECHNIQUE

The TiBAR technique was proposed from previous work performed at NAVWPNSUPPCEN Crane, reference 17, on cells under normal operating conditions. The technique is based on the theory that the rate of voltage drop on the discharge part of the life cycle is related to the life of the cell. Thus, the time it takes a cell to reach a given voltage during discharge (Ti) was used as a measurable indicator of life. This technique was also applied to the charge curve.

It was shown (reference 17) that if the time to reach 1.25 volts is small, the cell is not usually as good as one that required a longer time to reach 1.25 volts.

It was anticipated that the mean of each pack could be predicted from the eight test parameters and that cell to cell variation within a pack could be explained by the average of the Ti values (TiBAR). This theory was applied to the composite design by using the eight test parameters and TiBAR values as independent variables in regression analysis.

The time to discharge (Ti) to a voltage of 1.25 volts had been an arbitrary choice, therefore, the levels of 1.26, 1.24, 1.23, 1.22, 1.21, and 1.20 were also used. The time from one voltage level to another on the discharge curve (delta Ti) and the time to reach a specified voltage on the charge curve was also tried.

The TiBAR technique was to screen the cells by cycling each cell for a few cycles and from the data determine a good cell. Thus a maximum of 300 cycles was arbitrarily chosen. Since it was possible that the very early cycles might behave differently, several sets of cycles were used. TiBAR values in 50 and 100 cycle increments between one and 300 cycles were used in evaluating the regression equation.

The regression analyses using the TiBAR values were performed early in the program. At that time, only 18 of the 82 packs had failed. The 18 packs were those that had been operated under the extreme conditions of the test design.

The predicted values obtained from the regress analysis using the TiBAR's did not order the individual cells within a pack the same as had been observed in actual testing. This indicates that the TiBAR technique may not be able to distinguish the cell variation when accelerated conditions are used.

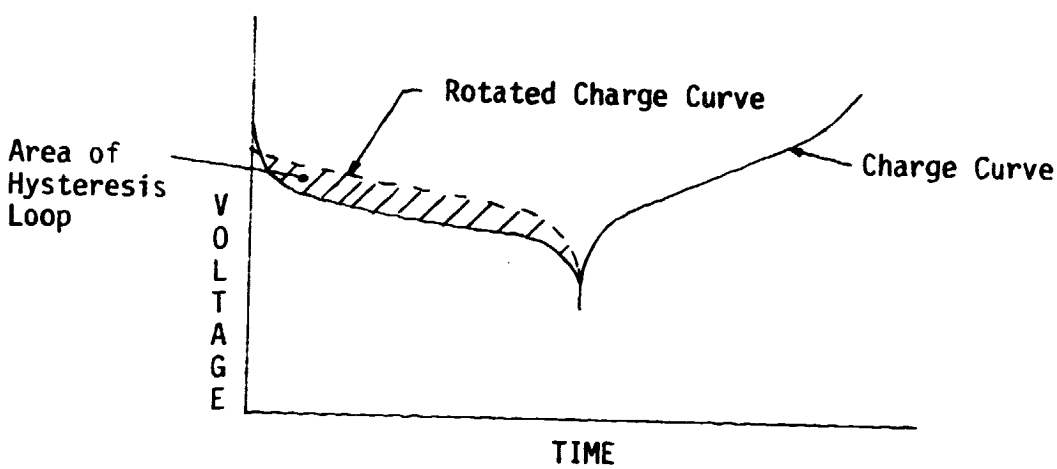
More benefit to the program might be obtained from the TiBAR technique if the analysis was reviewed and rerun using a data base of the full test design and knowledge learned from the ANOVA and regression of eight test parameters.

Some of the problems in using this technique could be related to how constant the test conditions were maintained. For example if the discharge current and temperature drift or change during the test, the value of Ti will change. This is also true of test interruptions. It is also noted that several of the cells in the 18 packs analyzed failed due to pressure, and it is not expected that discharge voltage would be indicative of a pressure failure. Another possible indicator of ordering life that could be evaluated is end of discharge voltage as a function of cycle. This is presently under investigation.

F. HYSTERESIS LOOP PREDICTIVE TECHNIQUE

The hysteresis loop is a technique for differentiating between good and bad cells or ordering cell failures in a pack. The technique was developed by Cryptanalytic Computer Sciences (CCS) under subcontract to NASA/GODDARD. Basically the hysteresis loop is a calculation of change in the area between the charge and discharge as a function of cycle. The charge voltage curve is "rotated" 180° and is in essence plotted on the same coordinates as the discharge voltage curves as illustrated in Figure II-1.

FIGURE II-1 EXAMPLE OF HYSTERESIS LOOP



As with the TiBAR technique, the hysteresis loop variable was to order the failures of the individual cell within the pack while the eight test parameters gave the average predicted life of the pack. Calculations were run when 18 of the 82 packs had failed. The predicted order of cell failure was not consistent and it was concluded that the hysteresis loop technique was not a good predictor. The reasons why the hysteresis loop was unsuccessful are probably similar to those for the TiBAR. But, it should also be noted that the technique was derived from data gathered on cells tested under more normal conditions. In developing this technique the difference in the length of time of the charge and discharge curve was small. In the accelerated test data this is not always true; thus, using this variable may have created some problems. It is suggested that future efforts using this technique on accelerated test data should be performed on normalized charge and discharge curves or another variable, such as ampere hours in and out.

The hysteresis loop should be attempted on selected packs where there was greater dispersion in cell failures and where cells failed primarily due to low voltage. There are two interesting features in the area curve in Figure II-2. Two different slopes can be seen. One slope is between 0 to 50 cycles and a second slope can be seen between 50 and 300 cycles. No attempt has been made to calculate these slopes for cells to determine if the slopes are related to cell failure order. It seems reasonable to assume that as a cell cycles (ages) the charge voltage would tend to increase and the discharge would decrease. This appears to be the case as seen in Figure II-2. It also seems reasonable to assume that the slope should be an indication of relative life of cells in a pack.

G. CHEMICAL AND PHYSICAL ANALYSIS

The initial test plan required chemical and physical analysis on 532 cells. The analysis consisted of the following:

1. Visual Inspection (cell in Discharged state).
2. Take gas sample and analyze for O_2, H_2, & N_2.
3. Cut cell open in N_2 atmosphere and weigh element.
4. Separator "Patch" for wet weight, dry weight, OH^-, and $CO_3^=$.
5. Soxhlet extraction of electrolyte in cell element.
6. Analysis of electrolyte for OH^- and $CO_3^=$.
7. Dry element weigh and disassemble.
8. Obtain weight and thickness of plates.

9. Analyze negative plates for Cd^+ and $Cd(OH)_2$.

10. Analyze positive plates for $Ni(OH)_2$ and Ni.

11. Measure residual electrochemical capacity of positive and negative plates from discharged cell and total electrochemical capacity.

Late in 1977 it became apparent that funds and time were insufficient to do a complete failure analysis on all of the cells and modifications were made. Most of the star point cells were analyzed (118 of 128). On the factorial packs it was decided to analyze one "average" cell and any "maveric" cell that failed outside the average. In early 1978 a further reduction was required. Only electrolyte and plate physical measurements were to be made on one average cell of the remaining packs. Cells and components of cells torn down are in storage so analysis can be performed if deemed necessary. At present there is considerable chemical and physical data which has not been adequately analyzed.

1. Gas Analysis

In most instances the gas analysis was made weeks or months after the cells failed and pressures were not recorded at the time of analysis. Therefore, the quantitative results cannot be related to the failure mechanisms.

2. Separator Patch Test

The separator patches were cut from a cell and soaked in deionized water for 24 to 36 hours. The wet weight and dry weight of the patch was determined. The solution was titrated to determine the concentration of OH^- and $CO_3^=$ ions. These patch test results should only be considered on a qualitative basis because in some instances the separator had to be scraped from the negative electrode and it is believed that $Cd(OH)_2$ interfered with the titration results. In general the separator patch test revealed there was less electrolyte in the separator of a cycled cell than an uncycled cell.

3. Cell Electrolyte Analysis

The electrolyte extracted from the cell was analyzed for KOH and K_2CO_3 by acid titration. The weight percent concentration of KOH in the cell was calculated by dividing the weight of KOH by the weight of the electrolyte extracted from the cells. The volume of electrolyte in the cell was calculated by dividing the weight of the electrolyte extracted from the cell by the specific gravity which was estimated from the concentration. The results are summarized in Table V-5 of Section V. Since the cells had varying concentrations and volumes built into different groups for the test, one cannot easily pick out differences or trends from the Table. Cells of like construction need to be grouped together for analysis. The weight

of K_2CO_3 found in cycled cells was about double the quantity found in uncycled cells. The data needs further analysis to determine how temperature or the cycle regime effects the change in the quantity of K_2CO_3.

4. Chemical Analysis of Positive and Negative Plates

The chemical analysis was performed on a set of three each positive and negative plates from each cell. The negative was analyzed for residual undischarged cadmium metal and cadmium hydroxide, $Cd(OH)_2$. The positive plates were initially analyzed for residual undischarged trivalent or tetravalent nickel and nickelous hydrozide, $Ni(OH)_2$. The quantity of the nickelic, undischarged material was negligible on the first several cells analyzed and this analysis was deleted. The results of the plate analysis are given in the Table V-2 in Section V, which also shows equivalent plate capacities. Total equivalent cell capacities were calculated and are presented in Table V-4 in Section V.

It was observed from the tables that the total cadmium in uncycled cells ranged from 16 to 18 Ah and in cycled cells from 15 to 17 Ah in uncycled cells which is a loss of 1.0 Ah. The calculated equivalent cell capacity of the positive plates in uncycled cells ranged from 9.0 to 10 Ah and in cycled cells it ranged from 10 to 11 Ah. Thus the positive plate chemical capacity increased 1.0 Ah during test which is indicative that some of the nickel sinter was oxidized during the cycle tests.

5. Electrochemical Analysis of Positive and Negative Plates

The flooded electrochemical capacity of three each positive and negative plates was measured in test cells. The plate being measured was the center plate of a three plate test cell with outside opposing electrodes of opposite polarity. The test plate was wrapped with a gas barrier RAI separator. The electrolyte was 31% KOH. The test plates were discharged initially at the C/2 rate to 0.5 V to measure residual capacity. The plates were then given three charge discharge cycles. The plates were charged at a C/3.33 rate. The positives were charged 200% and the negatives were charged 400%. The discharge on both positive and negative plates was performed at the C/2 rate to 0.5 V. The results of the measurements are given in Table V-2 of Section V. The material utilization is shown in the last two columns of the Table and was calculated by dividing the electrochemical capacity by the chemical capacity. Table V-4 lists the calculated equivalent electrochemical cell capacities of the plates and the negative to positive plate capacity ratios.

As with the chemical analysis, the electrochemical analysis showed negligible residual positive plate capacity. The uncycled negative plates showed negligible residual capacity (sometimes referred to as precharge) and the cycled plates varied from negligible to 0.47 Ah per plate, indicating that the residual capacity of the negative plate increased during cycling.

The calculated cell electrochemical capacity of the positive electrodes ranged from 6.8 to 8.4 Ah on uncycled cells and from 5.8 to 9.5 Ah on cycled cells. The calculated cell electrochemical capacity of the negative electrodes ranged from 8.6 to 14.2 Ah on uncycled cells and 3.7 to 12.6 Ah on cycled cells. This data needs further analysis before any conclusions can be drawn. A tentative conclusion is that many of the cells which failed due to loss of capacity, did not fail because of loss of capacity of the electrodes alone, but must be related to a cell system failure involving mass transfer. The negative and positive material utilizations vary considerably on the uncycled and cycled cells, and this needs further analysis to determine if there is a significant difference between cycled and uncycled cells.

6. Plate Weight and Thickness

The weight and thickness of each plate in an analyzed cell was measured. The measurements were averaged on a cell basis and are listed in Table V-2 in Section V. No significant difference in the weights of uncycled and cycled positive plates, but there is a slight loss in weight of the cycled negative (cadmium) plates. This difference is attributed to the migration of cadmium. There does not appear to be a significant change in thickness of the negative plates with cycling. There is a significant increase in the thickness of positive plates with cycling. Further analysis was performed to determine if there was a significant difference in thickness between the top and bottom of the plates. The results of this test showed that any differences between the top and bottom measurement that exists in cycled cells is similar to the difference that was found in cells that were not cycled.

The positive plate growth has been attributed to the corrosion of the nickel sintered material of the positive. This was suggested in references 26 and 29 and was related to the life of the cell. Additional analysis, found that the maximum cycle life of a given cell could be predicted based on the given increase in positive plate thickness. It was postulated that the maximum thickness a positive plate could obtain was 0.975 cm. This work is reported in Section VI.

7. Plate Lot Variations

As has been previously stated the cells were manufactured over a 2-year period and were made of three plate lots (No.'s 1, 2 and 4). It was assumed that no significant differences would exist between the lots, but differences were seen during analysis. It was determined that Lot 1 cells were significantly different than Lots 2 and 4 cells. This is not as bad as it first seems. Remember the Lot 1 cells only were used in the star point, and storage part of the matrix and Lot 2 and 4 comprized the factorial part of the matrix. Table II-6 summarizes the results from the uncycled cell analysis.

TABLE II-6 UNCYCLED CELLS - PLATE ANALYSIS

CELL LOT NO.	THICKNESS - cm		WEIGHT - gr		CHEM. CAP.Ah		ELECTROCHEM.CAP.Ah	
	POS.	NEG.	POS.	NEG.	POS.	NEG.	POS.	NEG.
1[a]	.0740	.0826	6.92	8.47	0.894	1.641	.700	0.98
2[b]	.0768	.0837	7.21	8.73	1.020	1.677	.812	1.042
4[b]	.0751	.0854	7.55	8.69	1.070	1.673	.832	1.17

a. Average of eight cells

b. Average of four cells

From the data in Table II-6 it is seen that cell Lot 1 plates are thinner, lighter and have less capacity than lots 2 and 4. The greatest difference is that the Lot 1 positive plates are 15 to 20% lower in chemical and electrochemical capacities. The effects of the test results are unknown, as the test plan was not designed to evaluate the difference in plate lots. In comparing cells, one must be aware of this difference and make a judgment of the effect this difference has on the test data being evaluated.

8. Cell Degradation and Failure Mechanism

The majority of the work performed on cell degradation and failure mechanism using the chemical and physical results has been done by Dr. P. McDermott of Coppin State University under contract with NASA/GODDARD (References 26, 29 and 30). He found that the nickel sinter of the positive plate was being oxidized and there was about an equivalent amount of charged cadmium being produced in the negative plate. He postulated that this could lead to high pressure failures because the cell would lose overcharge protection since the original excess $Cd(OH)_2$ was being reduced. He also theorized that the positive plate swelling contributed to cell failure by absorbing electrolyte and squeezing electrolyte from the separator. The drying out of the separator could contribute to low discharge voltage and high pressure by increasing the cell impedance and by restricting the diffusion of oxygen. Internal shorts would be enhanced by the compression of the separator and the fact that cadmium migrated into the separator.

SECTION III CONCLUSIONS AND RECOMMENDATIONS

The conclusions contained herein are based on the results obtained thus far on the accelerated test program in which 81 packs of 86 five cell packs put on test have completed cycling tests. The four normal condition packs (83N-86N), factorial pack 5N and center point pack 96N are still cycling. Five accelerating or stress parameters and three design parameters at five different levels were used. The stress parameters were depth of discharge, temperature, discharge rate, charge rate, and percent recharge. The design parameters were negative precharge, amount of electrolyte and concentration of electrolyte.

Eighteen of the test packs contained three extra cells, which were removed at 1/4, 1/2, and 3/4 of predicted life to measure degradation rate. Eight packs of three cells each were stored in a controlled temperature environment. These cells were removed from storage and analyzed to determine the effects of the temperature storage on the design factors and to correlate with cycling data. Chemical and physical analyses were performed on one uncycled cell of each design variable combination of the test matrix. In the following discussion, cycle life refers to cycles to 0.0 volts, and cycle hours refers to hours on cycle to 0.0 volts.

A. LIFE CYCLING

The test matrix produced cell failures over a wide range from 13 cycles to over 11,000 cycles. Many of the very early failures were due to the efficiency of the combination of test parameters being too low to substain long term cycling. Also, in reviewing the data, the following observations were made:

1. Some cells exhibited low voltage characteristics early in life, then became high later in life. Whether they failed first or not is unknown at this time.

2. The cells with a pressure transducer exhibited different voltage characteristics than cell without a pressure transducer. Statistical analysis showed no significant difference in cycle life between cells with and without pressure transducers.

B. CHEMICAL AND PHYSICAL ANALYSIS

The test procedures have been implemented in a production line operation. The following observations are made.

1. The gas analysis data must be accepted as qualitative results. In order to be of more quantitative benefit a gas sample must be taken immediately after termination of the test.

2. In cells cycled under the stress conditions of this test, cadmium hydroxide migrated into the separator and complicated the acid titration analysis of the electrolyte that was retained in the separator. Thus, the separator patch test can only be used for qualitative analysis. If quantitative results are to be obtained from this test, a solution to the cadmium hydroxide interference must be obtained. No interference occurred in the analysis of the electrolyte.

3. An additional problem in testing the separator is, that under extreme conditions, the separator is deteriorated so that an adequate sample cannot be obtained.

C. DATA ANALYSIS

1. Data Base

A large data base has been established from this program. This data base contains electrical cycling, manufacturer's tests, baseline tests, chemical and physical analyses. The data base is computerized so that either standard or specially written computer programs can be used as an effective tool in evaluating the electrical, chemical and physical make up of the cells. Information concerning the availability and use of this data base may be obtained from NAVWPNSUPPCEN Crane with NASA approval.

2. Composite Design

The data base is still incomplete but enough information is available to perform some analyses of the test matrix. Analysis of variances (ANOVA) have been performed on the fractional factorial data to determine the significant main effects and two-way interactions that affected life. For various reasons, some data points were missing creating an imbalance in the test design matrix. Therefore, the ANOVA was performed on the whole design and on separate parts so as to minimize the imbalance. These ANOVAs were evaluated and a "best" composite set of significant parameters was determined for each of the four failure criteria; cycles to 0.0 volts, hours to 0.0 volts, cycles to 1.0 volts and hours to 1.0 volts.

a. Test Parameters. The accelerated test data was used to initially evaluate the effects of the test parameters. The intent was to determine which parameters would be the best to use in a reduced accelerated test or a sampling plan. As expected, all five environmental parameters tested as being significant to cycle life of the cell in most of the cases, but in developing a reduced accelerated test or sampling plan we are looking for the factors that produce the best results. Temperature and depth of discharge appeared to have contributed the most to the variation in life of the cells. For both temperature and depth of discharge it appears that the log cycle life is an approximately linear function in the range of 20° C ≤ temperature < 45° C and 20% ≤ depth of discharge ≤ 100%, but the relationship is highly non-linear for higher temperatures. This indicates that temperature and depth of discharge can be used to accelerate a life cycle test, the results of which can then be extrapolated to normal (less stressful) test conditions.

Charge rate and discharge rate did not prove to be good accelerating factors in the given test design. An increase in the charge or discharge rate decreased the cycle hours; but at the same time, increased the cycle life. Also the combination of low charge and high temperature caused some packs to fail very early. Further testing needs to be done before charge and discharge rate could be considered reliable predictive accelerating factors.

Percent recharge was identified in the ANOVA as being significant. An increase in the percent recharge was associated with a decrease in cycle life and a small increase in cycle hours. But the combination of percent recharge and high charge rate attributed to the high number of pressure failures seen in the test. Thus percent recharge is not a good factor to use in an accelerated test plan.

Within the range evaluated (quantity of KOH 17.5 to 21.5 cc; concentration of KOH 22 to 38 % by weight; negative precharge 2.2 to 3.3 ah), the design variables, at the accelerated test design conditions, had very little effect on cycle life or cycle hours. The intent of these parameters was to evaluate significant trends in design. At present, design variables have not been analyzed enough to determine what levels are optimum. It is possible that the highly stressed test environment overwhelmed the significance of the design variables or the variation was not large enough.

b. Multiple Linear Regression. Stepwise multiple-linear regression was performed using as independent variables the composite sets of significant factors determined by the ANOVA. Eight equations resulted from the regression; one equation for each of the four failure criteria and for their natural logarithm. These equations provide the best fit of the data that is possible using the results of the ANOVA. The equations were then used with the test parameters to calculate the life of an average cell tested at these conditions and to predict the life of an average cell tested at the normal conditions. The prediction equations do not appear to extrapolate particularly well to the normal test conditions.

The predictions of the normal condition packs were, in most cases, lower than what the working group had anticipated and in some cases were lower than the actual life at the present time. It is noted that the order of the predictions is the same as what is expected. Additional analysis of the regression results is required to determine how accurately the equations have predicted the average cell of the composite design. The results do indicate that 75 to 80 percent of the variation in the cycle life of the cell can be explained by the environmental test factors. The remaining percent variation is due to either the individual cell variation or other variables not yet identified. In order for any method to be useful, it will be necessary to determine the cell-to-cell variation factor that distinguishes a "good" and "bad" cell by using such techniques as TiBAR, Hysteresis Loop or Discharge Curve Fitting. These techniques and others should be reviewed and applied appropriately to the data base presently available.

c. Discerning Individual Cell Performance. Two techniques (TiBAR and hysteresis loop) were tried to determine characteristics of individual cell performance. These attempts were performed at an early date of the program and were unsuccessful at determining individual cell performance within a pack. There were several reasons for failure, one of which was lack of data. In view of what has been learned from the present analysis and from the pack failure, further study of techniques for discerning individual cell performance is needed.

d. Non-linear Regression. In evaluating the test parameters it was found that in some cases non-linear functions could better describe the effect than could linear functions. Several non-linear equations were developed and tried. These equations have been based on only 2 or 3 factors; with further study, additional factors may be added and the equations improved.

3. Degradation Study and Failure Mechanisms

A considerable amount of chemical and physical analysis data has been obtained. As yet, the bulk of this data has not been analyzed, with most of the analysis being performed on the physical data. This analysis shows that the positive plates swell during cycling. The rate of thickening is strongly dependent on the levels of the test parameters, in particular on DOD. But whether or not plate thickening is a failure mechanism at low depth of discharge and temperature is questionable. There was very little positive plate thickening in the pack cycling at 20% DOD, even though this pack cycled 14,000 cycles.

The relationships of the other cell variables to the test conditions require further analysis. Some trends noted as a result of limited analysis of cell teardown data were:

a. Positive plates are exhibiting an increase in thickness. It is theorized that this is due to corrosion of the nickel sinter.

b. Negative plates show a decrease in total negative capacity when uncycled cells are compared with cycled cells. This decrease is probably due to cadmium hydroxide migration into the separator.

c. The negative charged active material increased.

d. The cadmium electrode does not thicken with life.

e. There is no significant difference in thickness between the top and bottom of electrodes.

D. RECOMMENDATIONS

This report has presented the results obtained from analyzing the composite design of the data base as of December 1978. This data base was not totally complete but is satisfactory for performing the analysis of variance and the linear regression. The "best" composite sets of significant factors have been determined and would not be changed by adding the remaining data to the data base. The regression equation based on the test parameters is the best that can be obtained at this time. Improvements might be possible once the data from the normal conditions are available and included. A more complete analysis of the results of the linear regression is required. It is recommended that the main effects and two-way interaction curves of the test parameters provided by the regression equation be analyzed.

Early in the program, attempts were made to determine characteristics of individual cell performance. These attempts failed for various reasons, one being a lack of data. It was decided to approach the problem by obtaining the data, then analyzing the data using just the test parameter, and finally to identify the characteristic of cell performance. The key to a successful prediction equation will be identification of a characteristic of cell performance. It is recommended that additional efforts be put forth to identify a characteristic of cell performance.

A better understanding of the failure mechanism(s) of this test is required. Sufficient data on the physical aspects of the failed cells exists. Additional chemical analysis should be performed. The minimum recommended is to complete analysis of the fractional factorial cells that have been partially analyzed.

Once the above work is performed the test conditions that should be used in [illegible] a small accelerated test or a sampling test can be identified. [illegible] identified the test conditions will have to be evaluated by normal tests.

SECTION IV

TEST PLAN AND RESULTS

The accelerated test program was designed to produce battery failures under stressful conditions and to relate these failures to those which might occur under normal space flight conditions. Five environmental parameters, temperature, depth of discharge, charge rate, discharge rate, percent recharge; and three design parameters, concentration of electrolyte, amount of electrolyte, and ampere-hours of precharge; at five levels of each factor were used to permit statistical evaluation of the effect of each factor and all two-factor interactions. This section describes the test design, a method of studying cell degradation, the cell design and the electrical testing performed.

A. COMPOSITE DESIGN

This accelerated test was designed statistically using eight factors (five environmental and three physical factors previously identified as important to the battery performance) at five levels of stress for each factor. Using these parameters, a full factorial design of 5^8 would require 390,625 test "points". To keep the number of test points required to a minimum while obtaining the desired information on the eight factors and five levels of each factor, a composite design concept was used. This design consists of three statistical elements identified by the terms, fractional factorial, star points and center point. Table IV-1 summarizes the eight factors and associated levels in the accelerated test program. Additional discussion on the theory of the composite design may be found in reference (7).

TABLE IV - 1 FACTORS AND LEVELS

ENVIRONMENTAL FACTORS	LEVELS 1*	2**	3***	4**	5*
1. Temperature °C (T)	20	30	40	50	60
2. Depth of Discharge %(DOD)	20	40	60	.80	100
3. Charge Rate (CR)	C/4	C/2	C	2C	4C
4. Discharge Rate (DR)	C/2	C	2C	4C	8C
5. Percent Recharged (%RC)	110	140	140	200	200
DESIGN FACTORS					
6. Concentration of Electrolyte (%KOH)	22	26	30	34	38
7. Amount of Electrolyte (CC)	17.5	18.5	19.5	20.5	21.5
8. Ampere-Hours of Precharge (AH)	2.20	2.50	2.80	3.00	3.30

* Star Point Levels
** Fractional Factorial Levels
*** Center Point Levels

NOTE: In the original proposed design the percent recharge of levels 3 and 5 had been 170 and 230 respectively. Since the specific parameters were based on engineering judgement, a proofing test was performed to validate these parameters. As a result of the test, the percent recharge level of 170 and 230 were changed to 140 and 200 respectively. These results are reported in reference 6.

1. Fractional Factorial

The fractional factorial part of the composite design is analyzed separately to determine which main effects and/or interactions have a significant affect on battery life. A 2^8 factorial matrix using two levels--a high and a low (level 2 and 4 of Table IV-1)--of the eight factors requires 256 test points. Since only the main effects and two factor interactions were to be analyzed, a one-fourth fractional replication was used to reduce the number of test points to 64. Figure IV-1 illustrates the full 2^8 factorial. The pack numbers (1N through 64N) are the test parameters of the test points used for the 1/4 X 2^8 factorial of the test design. The full 2^8 factorial would have a pack tested in each of the boxes in the figure.

FIGURE IV-1 FRACTIONAL FACTORIAL TEST MATRIX PACK NUMBER

NOTE: In the composite design Packs 20N, 24N and 36N were to be tested at the positions shown, but the actual parameters were those of positions A, B and C respectively.

% RECHARGE	% KOH	CC KOH	PC		TEMPERATURE °C 30° % DOD 40 CHARGE RATE C/2 DISCHG RATE C	30° 40 C/2 DISCHG RATE 4C	30° 40 2C DISCHG RATE C	30° 40 2C DISCHG RATE 4C	30° 80 C/2 DISCHG RATE C	30° 80 C/2 DISCHG RATE 4C	30° 80 2C DISCHG RATE C	30° 80 2C DISCHG RATE 4C	50° % DOD 40 C/2 DISCHG RATE C	50° 40 C/2 DISCHG RATE 4C	50° 40 2C DISCHG RATE C	50° 40 2C DISCHG RATE 4C	50° 80 C/2 DISCHG RATE C	50° 80 C/2 DISCHG RATE 4C	50° 80 2C DISCHG RATE C	50° 80 2C DISCHG RATE 4C
CYCLE PERIOD HRS.					2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00	2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00
200	34	20.5	3		5N							20N				49N	40N			
			2.5				56N			33N				4N					21N	
		18.5	3			64N					41N				12N			29N		
			2.5					13N	28N				57N							48N
	26	20.5	3			47N					58N				27N			14N		
			2.5					30N	11N				42N							63N
		18.5	3		22N							3N				34N	35N			
			2.5				39N			50N				19N					6N	
CYCLE PERIOD HRS.					1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76	1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76
140	34	20.5	3				35N	A		54N				23N					2N	
			2.5		18N							7N				38N	51N			
		18.5	3					26N	15N				46N							59N
			2.5			43N					62N				31N			10N		
	26	20.5	3					9N	32N				61N							44N
			2.5			60N					45N				16N			25N		
		18.5	3				52N			37N				8N					17N	
			2.5		1N				C			24N				53N	36N			B

2. Star Points and Center Point

The star points of the design take each extreme level (levels 1 and 5 of Table IV-1) of each factor in combination with the center level (level 3 of Table IV-1) of the remaining seven factors. The center point of the design is determined by the eight factors of the center level (level 3 of Table IV-1). This part of the composite design gives a method of evaluating the non-linear effect of the factors without a sizeable increase in the number of packs required. The star points required twice the number of factors, thus 16 packs for the eight factors, and center point required one pack. To complete the statistical design, a second pack having the same parameters as the center point was added to estimate the error that might be present due to the pack-to-pack variation. Table IV-2 illustrates the test parameters of the star and center points. The number of cells and packs for the complete composite design is summarized in Table IV-3.

TABLE IV-2 STAR POINTS AND CENTER POINT TEST MATRIX

Pack No.	STAR POINTS							
	Environmental Parameters					Physical Parameters		
	Temp (°C)	DOD (%)	Chg Rate	Disch Rate	Rechg (%RC)	KOH (%)	Prechg (ah)	KOH (cc)
65N	20	60	C	2C	140	30	2.80	19.5
66N	60	60	C	2C	140	30	2.80	19.5
67N	40	20	C	2C	140	30	2.80	19.5
68N	40	100	C	2C	140	30	2.80	19.5
69N	40	60	C/4	2C	140	30	2.80	19.5
70N	40	60	4C	2C	140	30	2.80	19.5
71N	40	60	C	C/2	140	30	2.80	19.5
72N	40	60	C	8C	140	30	2.80	19.5
73N	40	60	C	2C	110	30	2.80	19.5
74N	40	60	C	2C	200	30	2.80	19.5
75N	40	60	C	2C	140	22	2.80	19.5
76N	40	60	C	2C	140	38	2.80	19.5
77N	40	60	C	2C	140	30	2.20	19.5
78N	40	60	C	2C	140	30	3.30	19.5
79N	40	60	C	2C	140	30	2.80	17.5
80N	40	60	C	2C	140	30	2.80	21.5
	CENTER POINT							
81N 82N	40	60	C	2C	140	30	2.80	19.5

TABLE IV-3 SUMMARY OF TEST DESIGN

COMPOSITE DESIGN		
	Packs	Cells
Fractional Factorial	64	320
Star Points	16	80
Center Point	2	10
Total Required	82	410
SUPPLEMENTARY TESTS		
Normal Conditions	4	20
Uncycled Cells	-	30
Degradation Rate Evaluation		
a. Unfailed Removal	17	63
b. Temperature Storage	8	23
Total Required	19	136

3. Supplementary Tests

Additional tests that would correlate with the composite design and benefit the overall program were included. These supplementary tests are summarized in Table IV-3.

a. Normal Conditions. To determine the expected life of the cells in the program, cells were tested under "normal" conditions as shown in Table IV-4. Conditions for temperature of 0° C and percent recharge of 105 were not included in the composite design. Therefore, to tie these conditions into the design, a 2^2 factorial matrix using two levels of temperature (0° C and 20° C) and two levels of depth of discharge (20% and 40%) was selected.

TABLE IV-4 NORMAL CONDITIONS

ENVIRONMENTAL PARAMETERS						PHYSICAL PARAMETERS		
Pack No.	Temp (°C)	DOD (%)	Chg Rate	Disch Rate	Rechg (%RC)	KOH (%)	Prechg (ah)	KOH (cc)
83N	0	40	C/2.38	C/1.20	105	34	2.50	18.5
84N	20	20	C/4.76	C/2.40	105	34	2.50	18.5
85N	0	20	C/4.76	C/2.40	105	34	2.50	18.5
86N	20	40	C/2.38	C/1.20	105	34	2.50	18.5

b. Uncycled Cells. In order to establish a baseline upon which to compare the results of future chemical and physical analysis, sample cells were selected from each design variable combination. A design variable combination being a particular combination of the three design variables, concentration electrolyte (KOH %), ampere-hours of precharge (Prechg ah), and volume of electrolyte (KOH cc).

The composite design matrix contained 15 design variable combinations. Each combination was assigned a Group Number as shown in Table IV-5. Groups 8 and 13 have the same design variables, Group 8 corresponds to the normal points and Group 13 corresponds to the fractional factorial points. Two cells from each design variable combination were selected. One of the cells of each group was opened initially and all analyses performed. The second cell was stored for future reference.

TABLE IV-5 DESIGNATION OF DESIGN VARIABLE GROUP

GROUP NO.	KOH (%)	PRECHG (ah)	KOH (cc)
1	22	2.80	19.5
2	30	2.20	19.5
3	30	2.80	17.5
4	30	2.80	19.5
5	30	2.80	21.5
6	30	3.30	19.5
7	38	2.80	19.5
8	34	2.50	18.5
9	26	2.50	18.5
10	26	2.50	20.5
11	26	3.00	18.5
12	26	3.00	20.5
13	34	2.50	18.5
14	34	2.50	20.5
15	34	3.00	18.5
16	34	3.00	20.5

c. Degradation Rate Evaluation. Three cells were added to each of the star points, center point and normal conditions packs for early removal. One of the three cells was removed from each pack at an estimated one-fourth, one-half and three-fourths of life. These cells were subject to chemical and physical analysis to determine the mode and rate of degradation caused by the test conditions.

Table IV-6 lists the estimated cycles for removal of the scheduled cells. The estimates are based on temperature and depth of discharge cycle data resulting from test programs performed by the U. S. Air Force, NAVWPNSUPPCEN Crane and the Defense Research Establishment, Canada.

In order to determine the effect of temperature on the design variable, cells having the same design variables as the starpoints, center point and normal points were stored in a controlled temperature environment. Eight combinations of temperature and design variables were possible and are shown in Table IV-7. A cell was removed from controlled temperature storage when a scheduled removal cell was removed from the corresponding pack identified in Table IV-7. The cell was opened and chemically and physically analyzed for comparison with the scheduled removal cell.

d. Chemical and Physical Analysis. In addition to chemical and physical analysis of the scheduled removal, controlled temperature storage and uncycled cells, each failed cell was to be analyzed, but as the program progressed changes had to be made in the analysis schedule and are explained in Section V.

TABLE IV-6 SCHEDULED CELL REMOVAL

Pack No.	Estimated Cycles to Failure	Cycles to Cell Removal		
		1/4 Life First Cell	1/2 Life Second Cell	3/4 Life Third Cell
STAR POINTS				
65N	3000	750	1500	2250
66N	900	225	450	675
67N	9000	2250	4500	6750
68N	400	100	200	300
69N	2000	500	1000	1500
70N	1600	400	800	1200
71N	2800	700	1400	2100
72N	200	50	100	150
73N	1000	250	500	750
74N	500	125	250	375
75N	3000	750	1500	2250
76N	1000	250	500	750
77N	2000	500	1000	1500
78N	1000	250	500	750
79N	1800	450	900	1350
80N	1800	450	900	1350
CENTER POINT				
81N	2000	500	1000	1500
NORMAL POINTS				
83N	17000	4250	8500	12750
84N	27000	6750	13500	20250
85N	48000	12000	24000	36000
86N	13000	3250	6500	9750

TABLE IV-7 CONTROLLED STORAGE

PACK NO.	TEMP (C°)	KOH (%)	PRECHG (ah)	KOH (cc)	NO. CELLS	CORRESPONDING PACK
87N	20	30	2.80	19.5	3	65N
*88N	60	30	2.80	19.5	3	66N
89N	40	22	2.80	19.5	3	75N
90N	40	38	2.80	19.5	3	76N
91N	40	30	3.30	19.5	3	78N
92N	40	30	2.80	21.5	3	80N
93N	0	34	2.50	18.5	3	85N
94N	20	34	2.50	18.5	2	84N

*This pack deleted from the storage program because its corresponding pack, 66N, would not cycle at 60° C.

B. CELL DESIGN

The cells used as test samples in the program are nickel-cadmium cells, rated capacity of six ampere-hours (ah), manufactured by the General Electric Company per GSFC Specification S-716-P-6 and General Electric Manufacturing Document 232A2222AA-36; catalogue number 42B006AB62. General information on the various cell components is as follows.

1. Cell Case

The cell case was drawn 304 stainless steel with a wall thickness of 0.016 in. (0.040 cm) to 0.022 in. (0.056 cm). The wall thickness at the bend radii was 0.011 in. (0.028 cm) minimum.

2. Cell Header

The cell cover was fabricated from 304 stainless steel and contained two alumina ceramic seals with nickel iron (alloy 42) stress relief collars and nickel terminal posts. The braze used in the ceramic to metal seal was a nickel titanium alloy; the braze used to join the collar to the cover was a silver palladium alloy. Each terminal was tinned with solder. The header assembly has a 0.187 inch (0.475 cm) O.D. stainless steel fill tube welded to the cover.

3. Positive Plates

Each cell contains 10 sintered positive plates. The nominal dimensions of the plate, excluding the tab, were 2.170 in. (5.51 cm) high,

1.968 in. (5.00 cm) wide and 0.027 in (0.069 cm) thick. All edges of the positive plates were coined 0.08 in. (0.20 cm). The tab was an integral part of the nickel-plated steel grid. The nominal flooded capacity, at the two-hour discharge rate, was 0.75 ampere-hours per plate.

4. Negative Plate

Each cell contained 11 sintered negative plates. The nominal dimensions of the plate, excluding the tab, were 2.170 in. (5.51 cm) high, 1.968 in. (5.00 cm) wide and 0.0315 in. (0.08 cm) thick. All edges of the negative were coined 0.08 in. (0.20 cm). The tab was an integral part of the nickel-plated steel grid. The nominal flooded capacity, at the two-hour rate, was 1.3 ampere-hours per plate.

5. Separator

The separator used in the cells was a PELLON, Nylon 6, nonwoven material, style number 2505. Each positive plate had a separate, single thickness bag which was heat sealed on two edges with the fold along the bottom of the positive plate. The "as received" material is double water washed by the material manufacturer. No surfactants were added to the material by General Electric.

6. Insulation Wrapper

The electrode/separator assembly was insulated from the case walls by a film of polypropylene of 0.0050 in. (0.013 cm) nominal thickness.

7. Cell Variables

Three cell design parameters were varied, namely, concentration of electrolyte, volume of electrolyte and amount of negative precharge obtained by oxygen venting. No additives were added to the electrolyte. The 6 ampere-hour cell normally supplied by General Electric would have a 34 percent concentration of electrolyte, an 18.5 cc volume of electrolyte and a 2.50 ampere-hour negative precharge. These variables were:

	Physical Design Parameters				
Concentration of KOH electrolyte Percent by weight	22.0	26.0	30.0	34.0	38.0
Volume of electrolyte, cc.	17.5	18.5	19.5	20.5	21.5
Negative precharge, ah	2.20	2.50	2.80	3.00	3.30

8. Negative to Positive Ratio

The ratio of the full negative capacity to the full positive capacity is 1.7:1. The value is based on a measurement, per GSFC Specification S-716-P-6 made on five production cells of the standard design.

9. Pressure Transducers

One hundred and eighty-four of the cells were equipped with 5000 ohm potentiometric pressure transducers with a range of 0 to 300 PSIA. These transducers, Model 2-400, were manufactured by the Edcliff Instrument Company. They were attached to the cell fill tube by means of a Swagelok fitting. All other cells were capped off with a Swagelok fitting. The transducers and fittings were made from 304 or 316 stainless steel. All fitting assemblies were helium leak-checked before being installed on the cells and a final leak check was performed after assembly on the cells. Maximum leak rates were 10^{-7} Std. cc/sec. Figure IV-2 shows a cell with and one without a transducer.

10. Period of Manufacturer

The cells were fabricated by the manufacturer in three plate lots from 1973 to 1974, under contract with NASA/GSFC. The cell lot numbers assigned designates a particular negative and positive plate lot combination as follows.

	Plate Lot Number	
	Negative	Positive
Cell Lot 1	147	089
Cell Lot 2	197	146
Cell Lot 4	201	156

FIGURE IV-2 The cell on the left is fitted with a pressure transducer; the cell on the right is capped with a swagelok fitting.

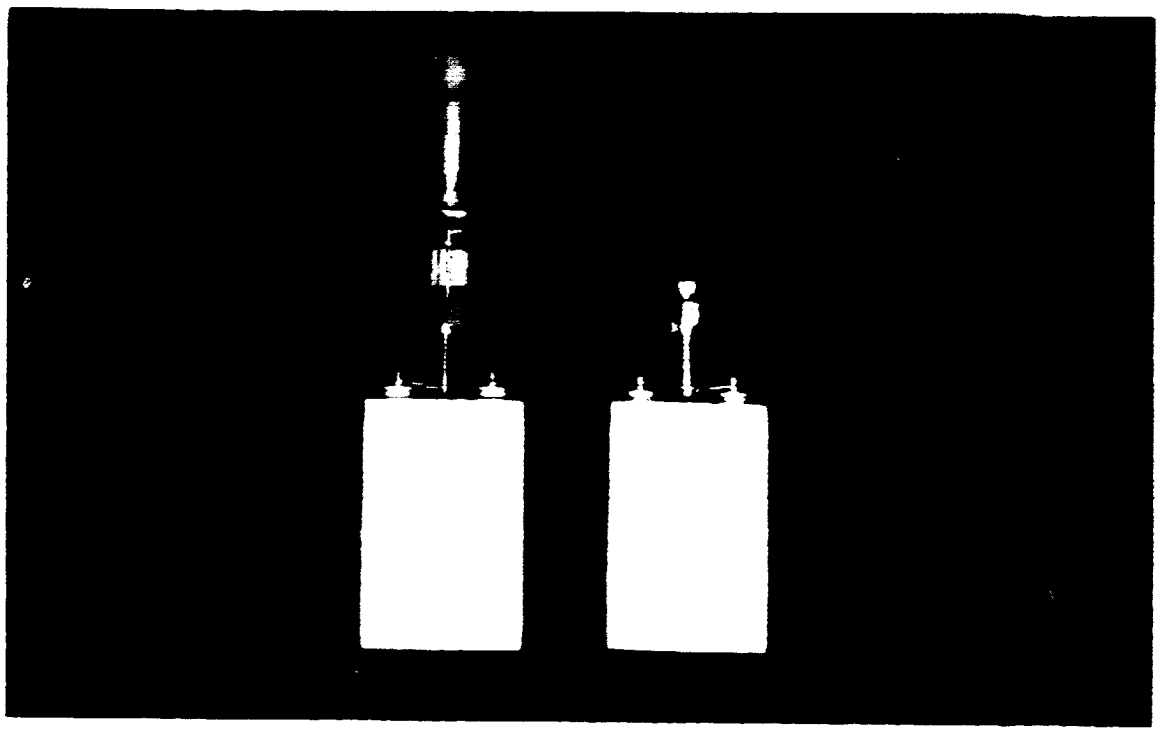


Table IV-8 lists the month and year that the cell formation test was run.

TABLE IV-8 CELL ACTIVATION DATE

PACK	CELL S/N-L	DATE	PACK	CELL S/N-L	DATE	PACK	CELL S/N-L	DATE	PACK	CELL S/N-L	DATE	PACK	CELL S/N-L	DATE
1N	054-4	10/74	17N	all 4	11/74	44N	all 4	11/74	63N	017-4	10/74	UN	007-1	2/73
	055-4	10/74	18N	all 2	8/74	45N	all 4	10/74		023-4	10/74	UN	019-1	2/73
	070-4	10/74	19N	all 4	10/74	46N	all 2	8/74		046-4	10/74	UN	033-1	2/73
	138-2	8/74	20N	all 2	8/74	47N	all 4	11/74		047-4	11/74	UN	047-1	2/73
	072-4	10/74	21N	all 2	8/74	48N	044-2	8/74		048-4	10/74	UN	062-1	2/73
2N	all 2	8/74	22N	all 4	11/74		053-4	10/74	64N	all 2	8/74	UN	038-1	2/73
3N	all 4	10/74	23N	all 2	8/74		015-2	6/74	65N	all 1	4/73	UN	067-1	2/73
4N	all 2	8/74	24N	all 4	10/74		016-2	6/74	66N	all 1	4/73	UN	001-1	2/73
5N	all 2	8/74	25N	all 4	10/74		017-2	6/74	67N	all 1	4/73	UN	013-1	2/73
6N	all 4	10/74	26N	all 2	8/74	49N	all 2	8/74	68N	all 1	4/73	UN	029-1	2/73
7N	all 2	8/74	27N	all 4	11/74	50N	068-4	10/74	69N	all 1	4/73	UN	230-1	4/73
8N	all 4	11/74	28N	all 2	6/74		069-4	10/74	70N	all 1	4/73	UN	056-1	2/73
9N	all 4	11/74	29N	all 2	8/74		132-2	8/74	71N	all 1	4/73	UN	213-2	4/73
10N	030-2	6/74	30N	all 4	10/74		133-2	8/74	72N	all 1	4/73	UN	130-2	8/74
	034-2	8/74	31N	037-2	8/74		134-2	8/74	73N	all 1	4/73	UN	129-2	8/74
	003-2	6/74		038-2	8/74	51N	all 2	8/74	74N	all 1	4/73	UN	181-2	8/74
	004-2	6/74		009-2	6/74	52N	all 4	11/74	75N	all 1	2/73	UN	182-2	8/74
	005-2	6/74		010-2	6/74	53N	058-4	10/74	76N	all 1	4/73	UN	086-2	8/74
11N	001-4	10/74		011-2	6/74		059-4	10/74	77N	all 1	2/73	UN	087-2	8/74
	002-4	10/74	32N	089-4	11/74		135-2	8/74	78N	all 1	2/73	UN	139-2	8/74
	022-4	11/74		049-4	10/74		136-2	8/74	79N	all 1	2/73	UN	025-2	6/74
	018-4	10/74		118-4	11/74		137-2	8/74	80N	all 1	2/73	UN	026-2	6/74
	020-4	10/74		117-4	11/74	54N	all 2	8/74	81N	all 1	4/73	UN	103-4	11/74
12N	all 2	8/74		116-4	11/74	55N	all 4	11/74	82N	all 1	12/74	UN	168-4	12/74
13N	035-2	8/74	33N	all 2	8/74	56N	all 2	8/74	83N	all 1	2/73	UN	052-4	10/74
	036-2	8/74	34N	all 2	11/74	57N	042-2	8/74	84N	all 1	2/73	UN	051-4	10/74
	006-2	6/74	35N	all 2	8/74		043-2	8/74	85N	all 1	2/73	UN	071-4	10/74
	007-2	6/74	36N	all 4	10/74		018-2	6/74	86N	all 1	2/73	UN	164-4	11/74
	008-2	6/74	37N	all 4	11/74		019-2	6/74	87N	all 1	4/73	UN	165-4	11/74
14N	021-4	10/74	38N	all 2	8/74		020-2	6/74	89N	all 1	4/73			
	026-4	10/74	39N	066-4	10/74	58N	all 4	11/74	90N	all 1	4/73			
	110-4	11/74		067-4	10/74	59N	all 2	8/74	91N	all 1	2/73			
	111-4	11/74		085-4	10/74	60N	all 4	10/74	92N	all 1	2/73			
	112-4	11/74		086-4	10/74	61N	all 4	11/74	93N	all 1	2/73			
15N	all 2	8/74		131-2	8/74	62N	041-2	8/74	94N	all 1	2/73			
16N	004-4	10/74	40N	all 2	8/74		021-2	6/74	96N	222-1	4/73			
	005-4	10/74	41N	all 2	8/74		022-2	6/74		226-1	4/73			
	024-4	10/74	42N	all 4	10/74		023-2	6/74		227-1	4/73			
	027-4	11/74	43N	031-2	6/74		024-2	6/74		297-1	12/74			
	028-4	11/74		039-2	8/74									
				012-2	6/74									
				013-2	6/74									
				014-2	6/74									

all -- Denotes all cells.
UN -- Denotes uncycled cells.

C. ELECTRICAL TESTING

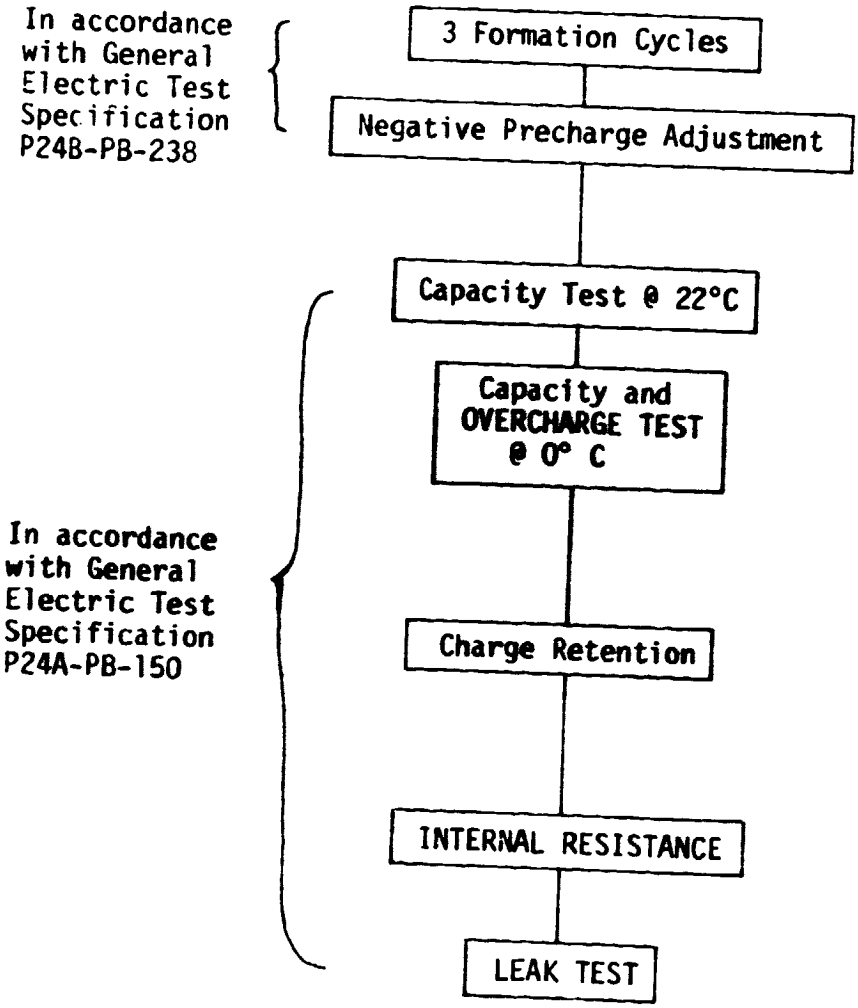
The manufacturer performed three formation cycles and subjected each cell to a negative precharge adjustment cycle and acceptance capacity test prior to delivery.

On receipt at NAVWPNSUPPCEN Crane, the cells were visually inspected, weighed and measured then assembled into packs of three, five or eight cells as specified by the test design. Cells in position 1 and 2 of the factorial packs and 1, 2 and 3 of the star point, center point and normal packs were equipped with pressure transducers. Cells designated for scheduled removal were assigned position numbers 6, 7 and 8. Packs to be performance cycled were subjected to baseline tests. At the completion of the baseline test the packs were life cycled to failure in accordance with the parameters of the test matrix. Packs designated for controlled storage were stored at the specified temperature when its corresponding pack began life cycling. When a cell reached a scheduled removal point, the cell was removed from the cycling pack, subjected to a series of post cycling tests and stored until chemical and physical analyses were performed. When a cell failed, the cell was removed from the pack and stored at the matrix temperature until all cells of the pack failed. When all cells failed, the pack was subjected to a series of post cycling tests and then stored until chemical and physical analyses were performed. The elapsed time between removal from test and post cycle testing and between post cycle testing and analyses varied from a few weeks to a few months.

1. Manufacturer's Tests

Each cell received three formation cycles, negative precharge adjustment cycle and acceptance tests, as shown in Figure IV-3. The data from these tests were supplied to the Government for review and analysis to determine if any correlation existed between the manufacturer's tests and the cycle life of a cell. Analysis of this data is contained in section VI. A detailed procedure of the manufacturer's tests can be found in reference 7.

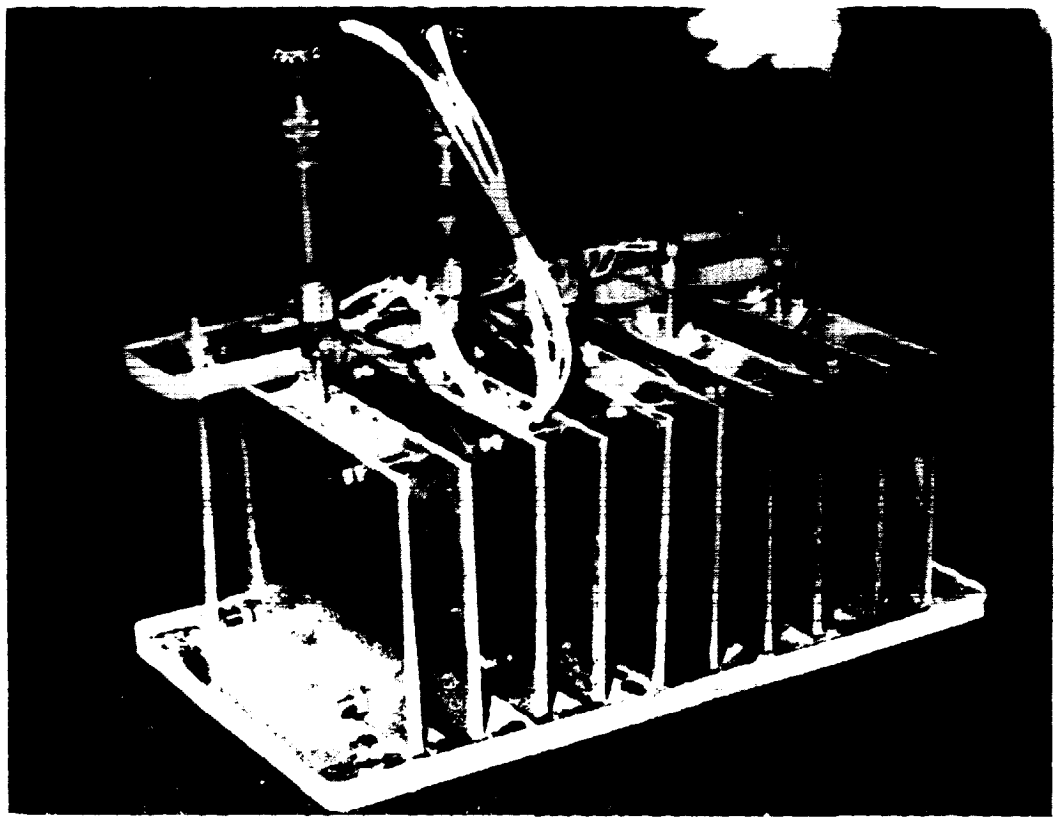
FIGURE IV-3 MANUFACTURER'S TESTS



2. Pack Construction

Each cell was coated with thermal grease and mounted between two 0.25 in. thick aluminum restraining plates which have a surface area four times that of the cell for heat transfer. A thermister was placed against the broad face of each cell through a hole drilled in the center of one restrainer plate. The cells were series connected and assembled into a pack on a plexiglass base. Each cell of the pack was separated from its neighboring cell by a 1 inch air space so that ambient air could circulate around the cells. The pack construction is shown in Figure IV-4.

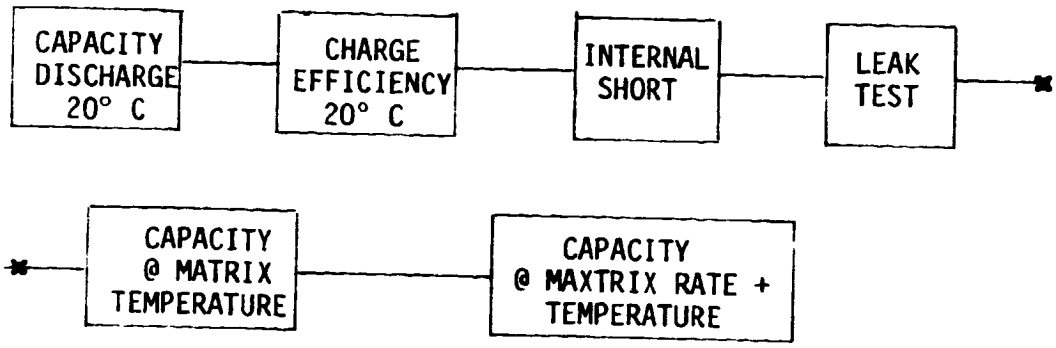
FIGURE IV-4 SAMPLE PACK ASSEMBLY



3. Baseline Tests

A flow chart of the baseline tests performed is shown in Figure IV-5 and the test procedure used is contained in Appendix A. The baseline tests were performed on each pack in order to obtain information as to the initial performance of the cells.

FIGURE IV-5 BASELINE TESTS



4. Cycling Test

Upon completion of the baseline tests the packs were cycled to failure or removal at the test parameters specified in Figure IV-1 and Table IV-2. Control and monitoring of the packs was performed utilizing the facilities described in Appendix B. A cell in a pack was considered to have failed when it would meet one of the following conditions:

Cell voltage during discharge reached 0.00 volts.

The pressure on cells having pressure transducers reached 250 psia. When all cells of a pack equipped with a pressure transducer failed, all remaining unfailed cells of that pack would be discontinued from cycling tests as a safety precaution.

Cycling tests began on the star point, center point and normal packs in September 1974. The fractional factorial packs were added from December 1974 to January 1977.

The working group became concerned when numerous pressure failures occurred early in life in the star point packs. From engineering judgement, it was determined that these pressure failures were not indicators of the true life of cells and that this high number could cast doubt on the successful outcome of the test. Thus the pressure failure criteria for the fractional factorial packs was changed to: when the last cell of a pack equipped with a pressure transducer failed, this failure cycle would be noted and cycling of this cell and all remaining cells would continue until the cell equipped with a pressure transducer failed by another mode.

Unforseen problems of system malfunctions and human error, occurred during the 4 years of testing that had an impact on the results. These problems were dealt with at the time they occurred and, where possible, the impact on the cycling of the pack(s) concerned has been evaluated. A Pack Performance Summary (Reference 3) was prepared that gives a detailed summary of the life cycling of each pack. Appendix D provides an abbreviated pack summary containing significant information about the failure of a cell and anomalies that occurred.

The following paragraphs summarize the types of anomalies which occurred during electrical testing.

Pack 88N was discontinued from temperature storage at 60° C after 6 weeks because all cells in its corresponding pack (66N) failed after 13 cycles.

Pack 82 N (this pack had parameters identical to 81N and was to be used to determine the pack-to-pack variation) failed prematurely when the test equipment malfunctioned causing the cells to reverse and finally short. A pack (designated as 96N) containing four cells, three cells from pack 88N and one uncycled cell, having design variables identical to pack 81N was placed on test as a replacement for pack 82N.

Wrong test conditions. A programming error resulted in pack 20N being tested at 40% DOD and 140% Recharge instead of 80% DOD and 200% Recharge.

Pack 36N was inadvertently tested at a temperature of 30° C instead of 50° C. To compensate for this error pack 24N's temperature parameter was switched from 30° C to 50° C. The change in pack 24N's temperature parameter, was later found to be an error in judgement as it did not compensate for pack 36N but created a greater imbalance in the factorial matrix when statistical analysis was performed.

Hardware Malfunctions. During the electrical cycling tests various conditions interrupted cycling. Procedures were established to handle these interruptions as follows:

a. Power Outages. In the event of a power outage the Automatic Data Acquisition and Control System (ADACS) placed the packs on open-circuit stand. When power was restored, cycling resumed at the point of power interruption.

b. Temperature Control. Packs were tested in environmental test chambers. Instances occured in which the chamber control malfunctioned allowing packs to cycle above or below the test temperature. When such a malfunction occurred the test chamber was shutdown and repaired, and cycling continued.

c. Test Unit Malfunction. Each pack cycled using its own individual test control unit. If the unit malfunctioned, the pack could be overdischarged or overcharged which may have induced a premature cell failure.

d. Current Drift. The packs were charged and discharged by constant current means. The test parameters varied slightly when the power supply would drift from the setpoint. When personnel observed a wrong current they would manually correct the power supply.

5. Cycling Test Results

Factorial Pack 5N and Center Point Pack 96N are still cycling with 2 and 3 cell failures respectively. Normal test Packs 83N, 84N, 85N, and 86N are still cycling with one failure each in Packs 83N and 86N. Table IV-9 summarizes the cycling test data. The first five columns contain cell identification information as follow:

Pack - Pack number identifies the test parameters of Figure IV-1 and Table IV-2 at which the Pack was tested.

Cell - Cell's position within a pack. Cells 1 and 2 of the factorials; Cells 1, 2 and 3 of the star, center and normal packs had pressure tranducers fitted to them. Cells 6, 7 and 8 were designated for removal from test at a specified cycle.

Group - Cell's physical design group (Concentration of Electrolyte, Precharge AH, and Amount Electrolyte) to which the cell belonged.

Serial - Cell's identifying serial number.

Lot - The manufacturers designated cell lot. The combination of a serial number and lot number identify each individual cell.

The "Fail Mode" column contains a symbol (or symbols) indicating why a cell was removed from tests:

S - Cell shorted during testing. A short was defined as no voltage on charge or discharge.

L - Low voltage failure. A low voltage failure was one in which the cell reached 0.0 volts during discharge.

P - Pressure Failure. A cell fitted with a pressure transducer fails when pressure exceeds 250 psia.

A - Safety Removal. A cell not fitted with a pressure transducer that did not fail, but was removed from testing as a precaution when all cells of the pack equipped with a pressure transducer failed.

R - Scheduled Removal. Cells were designated prior to the start of test to be removed on a specified cycle. These cells are identified by position number 6, 7 and 8.

D. DATA MANAGEMENT

The collection, management and reduction of the data on 95 packs (546 cells) has been a major task since the beginning. During cycling tests, the Automatic Data Acquisition and Control System (ADACS) described in Appendix B was programmed to record data on magnetic tape (at 36 second intervals) for every cycle of each pack during the early part of life. Thereafter, only beginning and end of charge and discharge of each cycle were recorded. In December 1977, this was changed to: record three full cycles (at 36 second intervals) at 50 cycle intervals on fractional factorial packs and at 100 cycle intervals on normal conditions packs. This provides information on the characteristic curve during life. This "raw" data was stored, on the magnetic tape, in chronological order. Periodically, this data was sorted and merged so that data of each pack for that period of time would be together.

As of September 1978, there were 683 raw data tapes generated since June 1974 and 357 periodic tapes divided into seven periods. In order to obtain a complete record on one or more packs, the computer would have to retrieve data from 20 or more tapes. This was an expensive and time consuming procedure. Thus, a "master" tape set was generated from the periodic tapes by sorting and merging all data for a pack onto one or more tapes and filed by pack number. This reduced the number of tapes from 375 to 123. Additional files have been generated, from the master tapes, to be used in the analysis of the data. One such file is the Selected N Pack Data Set, which contains selected cycles throughout the life of each pack. The selection was based on an algorithm that recorded data on three complete successive cycles in 30 evenly-spaced periods and the last 10 cycles prior to a cell failure for the life of each pack. This file contains four tapes. A second subset of tapes, N Pack Endpoint, contains the beginning and end of discharge and charge for every cycle of each pack. This data is contained on 88 tapes.

The raw data endpoints from the manufacturer's and baseline tests were keypunched onto 80-column cards to be used in evaluating relationships between this data and cycling data. The raw data from the chemical and physical analyses is keypunched on 80-column cards, sorted and stored in a data file, inputed into a program that calculates and outputs the results of the test.

A Correlation Data File was prepared and contains 72 variables measured for each cell, along with cell-identification information, test matrix parameters, and cycles at which the cell end of discharge voltage was 1.1, 1.0, 0.5 and 0.0 volts. The first 24 of the 72 variables are the results of the chemical and physical analyses; variables 25 through 48 are endpoint data from the manufacturer's tests and variables 49 to 72 are the endpoint data of the basetime tests performed at NAVWPNSUPPCEN Crane. This data file has been used in determining whether correlations exist between the variables or with life.

Several computer programs were written and are used to sort and merge the raw data into various data files and to determine the chemical and physical test results. Where possible, existing programs have been used to analyze the results. The Statistical Package for Social Studies was used in performing the analysis of variance, stepwise multiplelinear regression, and for obtaining correlations between two variables.

TABLE IV-9 CYCLE TEST RESULTS

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.9 VOLT	CYCLES TO 0.8 VOLT
1N	1	09	055	4	S	8144		8141	5624	8133	8136	8141
1N	2	09	054	4	PL	9148	7190	9148	6298	8376	9130	9143
1N	3	09	130	2	L	10914		10914	9314	10653	10909	10914
1N	4	09	072	4	L	10791		10791	10471	10532	10791	10791
1N	5	09	070		S	12745		12745	12744	12744	12745	12745
2N	1	16	163	2	S	965		964	143	190	964	964
2N	2	16	164	2	L	948		948	136	186	948	948
2N	3	16	140	2	L	844		840	129	187	840	840
2N	4	16	141	2	L	947		947	142	190	947	947
2N	5	16	143	2	L	946		945	150	193	945	945
3N	1	11	091	4	L	1671		1600	34	567	1569	1600
3N	2	11	092	4	M	474		474	30	418	0	0
3N	3	11	140	4	L	1613		1609	23	1457	1569	1609
3N	4	11	141	4	L	1792		1791	22	1464	1791	1791
3N	5	11	142	4	L	1544		1536	22	1338	1536	1536
4N	1	14	045	2	S	3533		3532	27	169	3532	3532
4N	2	14	046	2	L	3320		3318	19	177	3302	3318
4N	3	14	062	2	S	3093		3092	30	223	3092	3092
4N	4	14	063	2	L	3014		3014	32	190	3012	3014
4N	5	14	064	2	S	3375		3374	34	235	3374	3374
5N	1	16	166	2								
5N	2	16	165	2	P							
5N*	3	16	146	2	L	9442	1446	1446				
5N	4	16	145	2								
5N	5	16	144	2								
6N	1	09	056	4	L	601		601	142	601	601	601
6N	2	09	057	4	M	485		485	0	0	0	0
6N	3	09	073	4	L	811		810	134	806	810	810
6N	4	09	074	4	L	747		747	134	745	746	747
6N	5	09	075	4	L	704		704	140	702	703	704
7N	1	14	047	2	L	3136		3136	65	740	3133	3136
7N	2	14	048	2	PL	2916	2915	2915	53	583	2915	2915
7N	3	14	065	2	L	3035		3034	18	593	3028	3034
7N	4	14	066	2	L	2686		2650	60	557	2643	2650
7N	5	14	067	2	L	3293		3298	40	837	3296	3298
8N	1	11	138	4	L	3796		3795	30	174	3790	3795
8N	2	11	139	4	L	2566		2563	25	349	2561	2563
8N	3	11	161	4	L	4192		4192	76	320	4188	4192
8N	4	11	162	4	L	4099		4099	95	429	4098	4099
8N	5	11	163	4	S	4661		4661	97	603	4661	4661
9N	1	12	015	4	P	10582	1.211	10211	659	7350	0	0
9N	2	12	019	4	PL	15516	11097	15513	869	7408	15215	15513
9N	3	12	106	4	M	17135		17135	751	7470	16815	0
9N	4	12	107	4	M	12146		12146	966	7568	0	0

* UNVERIFIED FAILURE

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
9[illegible]	5	12	108	4	H	17403		17403	750	7074	0	0
10N	1	13	030	2	L	32		11	7	9	11	11
10N	2	13	034	2	L	32		13	8	11	13	13
10N	3	13	003	2	L	32		20	9	13	20	20
10N	4	13	004	2	L	32		19	8	13	15	19
10N	5	13	005	2	L	32		20	9	15	20	20
11N	1	10	001	4	H	1575		1575	0	0	0	0
11N	2	10	002	4	H	1568		1568	1051	1133	0	0
11N	3	10	022	4	S	2582		2582	2396	2582	2582	2582
11N	4	10	018	4	S	2003		2003	1860	2001	2003	2003
11N	5	10	020	4	S	2402		2402	2382	2402	2402	2402
12N	1	15	124	2	P	1025	910	910	0	0	0	0
12N	2	15	125	2	P	1025	920	920	0	0	0	0
12N	3	15	088	2	L	2037		2034	1641	2003	2034	2034
12N	4	15	089	2	L	2052		2051	1767	2035	2047	2051
12N	5	15	090	2	L	2055		2054	1729	1970	2054	2054
13N	1	13	035	2	PH	8020	9236	8020	782	4495	7961	0
13N	2	13	036	2	S	4258		4258	711	4254	4258	4258
13N	3	13	006	2	S	2695		2695	787	2692	2692	2695
13N	4	13	007	2	S	10818		10818	1078	4762	10818	10818
13N	5	13	008	2	H	12179		12179	994	4939	0	0
14N	1	12	021	4	L	36		27	8	14	25	27
14N	2	12	026	4	L	36		26	7	18	20	26
14N	3	12	110	4	L	41		34	10	26	31	34
14N	4	12	111	4	L	36		32	10	24	29	32
14N	5	12	112	4	L	41		33	8	24	30	33
15N	1	15	123	2	P	899	895	895	317	0	0	0
15N	2	15	122	2	L	3242		3242	307	3125	3237	3242
15N	3	15	093	2	H	1717		1870	276	326	0	0
15N	4	15	091	2	L	2707		2700	255	2679	2699	2700
15N	5	15	092	2	H	1717		1840	259	1634	1698	0
16N	1	10	004	4	P	1051	1003	1003	0	0	0	0
16N	2	10	005	4	L	4202		4202	2856	3644	4162	4202
16N	3	10	024	4	S	5692		5691	3655	4166	5691	5691
16N	4	10	027	4	L	6253		6253	2895	4280	6252	6253
16N	5	10	028	4	S	5653		5652	3682	5249	5652	5652
17N	1	11	095	4	P	1221	1085	1085	130	0	0	0
17N	2	11	096	4	L	1351		1351	140	1351	1351	1351
17N	3	11	143	4	L	1333		1333	146	1333	1333	1333
17N	4	11	144	4	L	1265		1265	147	1265	1265	1265
17N	5	11	145	4	S	1333		1329	156	1329	1329	1329
18N	1	14	050	2	L	7301		7301	6085	6123	7285	7301
18N	2	14	049	2	L	12467		12467	8842	9401	12466	12467

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
18N	3	14	070	2	L	10483		10483	8594	10482	10483	10483
18N	4	14	069	2	L	5221		5221	5145	5181	5196	5221
18N	5	14	068	2	L	6707		6707	5254	6707	6707	6707
19N	1	09	080	4	L	2763		2760	27	251	2745	2760
19N	2	09	081	4	S	1760		1734	20	189	1732	1734
19N	3	09	076	4	H	2909		2909	59	515	0	0
19N	4	09	077	4	S	2344		2342	61	543	2342	2342
19N	5	09	078	4	H	2930		2830	86	560	0	0
20N	1	16	167	2	HS	6178	2939	6178	1418	6178	6178	6178
20N	2	16	169	2	P	1654	621	621	0	0	0	0
20N	3	16	147	2	S	14366		14366	5037	10685	14366	14366
20N	4	16	148	2	S	10514		10513	5710	10511	10513	10513
20N	5	16	149	2	S	12334		12334	5690	10911	12334	12334
21N	1	14	051	2	S	426		425	78	421	425	425
21N	2	14	053	2	P	117	102	102	70	0	0	0
21N	3	14	071	2	S	450		449	63	449	449	449
21N	4	14	072	2	S	489		489	58	483	488	489
21N	5	14	073	2	S	420		420	64	417	419	420
22N	1	11	100	4	L	4893		4891	4177	4446	4766	4891
22N	2	11	098	4	L	2722		2722	2090	2224	2714	2722
22N	3	11	148	4	L	7577		2176	2115	2152	2172	2176
22N	4	11	146	4	L	3285		3285	2798	2976	3255	3285
22N	5	11	147	4	L	2178		2178	1983	2037	2134	2178
23N	1	16	170	2	L	593		553	20	109	523	553
23N	2	16	171	2	L	519		480	22	111	442	480
23N	3	16	150	2	L	4609		4609	30	159	4609	4609
23N	4	16	151	2	L	4652		4650	34	177	4650	4650
23N	5	16	152	2	S	4585		4583	43	184	4583	4583
24N	1	09	062	4	PL	2041	1577	2041	72	1063	2021	2041
24N	2	09	063	4	P	1517	1486	1486	21	1067	0	0
24N	3	09	079	4	L	1944		1944	23	1013	1903	1944
24N	4	09	080	4	L	1895		1895	25	988	1857	1895
24N	5	09	081	4	L	1868		1868	28	913	1804	1868
25N	1	10	006	4	L	43		34	10	26	32	34
25N	2	10	007	4	L	43		20	8	14	18	20
25N	3	10	029	4	L	43		35	11	27	33	35
25N	4	10	030	4	L	43		35	11	28	33	35
25N	5	10	031	4	L	49		38	11	31	35	38
26N	1	15	120	2	L	3745		3745	1079	3324	3667	3745
26N	2	15	121	2	S	12152		12151	945	5024	12151	12151
26N	3	15	094	2	L	11067		11067	366	4515	10695	11067
26N	4	15	095	2	L	11064		11064	493	5030	11053	11064
26N	5	15	096	2	S	12096		12095	612	5106	11682	12096

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
27N	1	12	041	4	PL	2715	2231	2715	2227	2714	2715	2715
27N	2	12	045	4	H	2260		2254	0	0	0	0
27N	3	12	113	4	L	2537		2537	1650	2533	2537	2537
27N	4	12	114	4	S	2694		2694	1671	2689	2694	2694
27N	5	12	115	4	S	2708		2708	1654	2706	2708	2708
28N	1	13	027	2	L	2033		2033	372	1657	2032	2033
28N	2	13	028	2	L	2564		2561	392	2537	2560	2561
28N	3	13	029	2	H	2231		2231	342	0	0	0
28N	4	13	001	2	S	2371		2369	356	2366	2369	2369
28N	5	13	002	2	S	2155		2155	342	2148	2155	2155
29N	1	15	118	2	L	35		18	7	11	15	18
29N	2	15	119	2	L	34		17	7	10	14	17
29N	3	15	097	2	L	33		17	6	9	15	17
29N	4	15	100	2	L	34		18	7	12	16	18
29N	5	15	098	2	L	34		19	7	13	17	19
30N	1	10	008	4	PL	5599	4324	5599	985	5599	5599	5599
30N	2	10	009	4	L	3570		3569	814	1929	3542	3569
30N	3	10	032	4	S	5757		5755	890	5754	5755	5755
30N	4	10	033	4	S	5621		5620	1128	5603	5619	5620
30N	5	10	034	4	L	7459		7459	1135	6485	7233	7459
31N	1	13	037	2	L	3241		3239	374	3231	3239	3239
31N	2	13	038	2	L	4690		4690	330	4682	4690	4690
31N	3	13	009	2	S	4613		4613	358	4613	4613	4613
31N	4	13	010	2	S	4449		4449	324	4448	4448	4449
31N	5	13	011	2	L	4755		4755	332	4751	4754	4755
32N	1	12	089	4	H	645		645	376	0	0	0
32N	2	12	049	4	PS	3166	2931	3166	2403	2888	3166	3166
32N	3	12	118	4	L	2952		2952	2419	2952	2952	2952
32N	4	12	117	4	H	2933		2933	2426	0	0	0
32N	5	12	116	4	L	2402		2398	2026	2296	2395	2398
33N	1	14	054	2	PL	2016	1829	1913	23	244	1843	1913
33N	2	14	055	2	P	1778	1771	1771	23	273	0	0
33N	3	14	074	2	L	2075		2075	13	174	1882	2075
33N	4	14	075	2	L	2220		2207	15	258	1938	2207
33N	5	14	076	2	L	2327		2327	14	194	2005	2327
34N	1	11	101	4	P	2778	2712	2712	286	0	0	0
34N	2	11	131	4	PS	3206	3052	3206	299	2857	3206	3206
34N	3	11	149	4	S	3159		3158	288	2243	3150	3158
34N	4	11	150	4	S	2966		2966	234	2548	2966	2966
34N	5	11	151	4	S	3395		3395	275	2524	3395	3395
35N	1	16	172	2	P	429	258	258	0	0	0	0
35N	2	16	173	2	P	250	111	111	0	0	0	0
35N	3	16	153	2	L	4084		4077	980	4077	4077	4077
35N	4	16	154	2	S	4045		4044	1013	4044	4044	4044

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
35N	4	16	155	2	L	5907		5907	978	5901	5907	5907
36N	1	09	064	4	L	1370		1369	642	1184	1249	1369
36N	2	09	065	4	L	1398		1398	672	1235	1394	1398
36N	3	09	084	4	L	1368		1360	637	1185	1249	1360
36N	4	09	083	4	L	1357		1247	639	1165	1229	1247
36N	5	09	082	4	L	1328		1241	639	1169	1229	1241
37N	1	11	132	4	L	1454		1454	26	850	1454	1454
37N	2	11	133	4	L	1300		1293	26	761	1290	1293
37N	3	11	152	4	L	1215		1187	33	380	1149	1187
37N	4	11	153	4	L	1215		1213	33	391	1210	1213
37N	5	11	154	4	L	1300		1295	27	393	1295	1295
38N	1	14	056	2	L	7422		7422	120	1602	7421	7422
38N	2	14	057	2	P	5783	5650	5650	182	1660	0	0
38N	3	14	077	2	L	6172		6172	83	2158	6172	6172
38N	4	14	078	2	L	6937		6937	92	2023	6934	6937
38N	5	14	079	2	L	6405		6404	182	2350	6402	6404
39N	1	09	066	4	L	4960		4955	4671	4943	4954	4955
39N	2	09	067	4	S	8608		8608	1006	8608	8608	8608
39N	3	09	085	4	L	9640		9640	985	6908	9627	9640
39N	4	09	086	4	S	5227		5227	1240	5227	5227	5227
39N	5	09	131	2	L	7102		7102	988	6827	7102	7102
40N	1	16	174	2	H	443		443	0	0	0	0
40N	2	16	175	2	L	734		733	602	501	729	733
40N	3	16	196	2	L	590		541	484	505	536	541
40N	4	16	197	2	L	627		587	441	577	586	587
40N	5	16	198	2	L	475		438	413	438	438	438
41N	1	15	117	2	S	728		727	264	727	727	727
41N	2	15	116	2	L	819		816	138	816	816	816
41N	3	15	101	2	L	809		809	152	805	809	809
41N	4	15	102	2	L	405		401	138	395	400	401
41N	5	15	103	2	L	578		576	137	570	575	576
42N	1	10	010	4	L	830		832	817	829	832	832
42N	2	10	011	4	P	554	523	523	0	0	0	0
42N	3	10	035	4	S	685		682	682	682	682	682
42N	4	10	036	4	L	958		958	957	958	958	958
42N	5	10	037	4	L	966		966	899	966	966	965
43N	1	13	031	2	L	10222		10221	240	2197	10101	10221
43N	2	13	039	2	L	6750		6750	200	1872	6692	6750
43N	3	13	012	2	L	10677		10677	285	2157	10496	10677
43N	4	13	013	2	L	9576		9572	315	2119	9374	9572
43N	5	13	014	2	L	10083		10081	292	2263	9968	10081
44N	1	12	090	4	P	2309	1675	2302	24	383	2285	2302
44N	2	12	093	4	P	1599	1591	1591	38	490	0	0

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	DEVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
44N	3	12	119	4	L	2371		2369	30	416	2345	2369
44N	4	12	120	4	L	2540		2537	27	498	2469	2537
44N	5	12	121	4	L	2619		2609	28	542	2570	2609
45N	1	10	012	4	P	521	483	483	251	0	0	0
45N	2	10	013	4	L	1961		1960	302	1959	1960	1960
45N	3	10	038	4	L	537		537	407	532	533	537
45N	4	10	039	4	S	1611		1610	247	1610	1610	1610
45N	5	10	040	4	L	1537		1525	244	1521	1525	1525
46N	1	15	114	2	L	3205		3205	3056	3101	3202	3205
46N	2	15	115	2	L	3174		3015	3010	3012	3015	3015
46N	3	15	104	2	L	2973		2966	2969	2874	2962	2966
46N	4	15	105	2	L	3174		3173	2903	3173	3173	3173
46N	5	15	106	2	L	3192		3192	2729	3156	3192	3192
47N	1	12	094	4	PL	8023	7989	8018	239	4670	7701	8018
47N	2	12	097	4	L	7776		7776	347	4181	7527	7776
47N	3	12	122	4	L	7513		7513	265	4771	6957	7513
47N	4	12	123	4	L	7776		7776	462	4691	7585	7776
47N	5	12	124	4	L	6783		6603	373	4266	6584	6603
48N	1	13	044	2	S	827		827	15	117	827	827
48N	2	13	093	4	P	574	570	570	18	204	0	0
48N	3	13	015	2	S	756		754	21	125	754	754
48N	4	13	016	2	S	793		792	18	104	792	792
48N	5	13	017	2	S	814		813	20	130	813	813
49N	1	16	176	2	PL	3946	3466	3966	184	3160	3946	3946
49N	2	16	177	2	P	1657	1647	1647	276	0	0	0
49N	3	16	159	2	L	3764		3764	247	3162	3764	3764
49N	4	16	160	2	S	3058		3057	256	1944	3057	3057
49N	5	16	161	2	L	3939		3939	256	3594	3939	3939
50N	1	09	068	4	PL	1726	1663	1695	20	198	1674	1695
50N	2	09	069	4	L	1578		1577	16	267	1566	1577
50N	3	09	131	2	L	1726		1726	18	192	1597	1726
50N	4	09	133	2	L	1726		1698	18	162	1609	1698
50N	5	09	134	2	L	1726		1726	30	391	0	0
51N	1	14	058	2	H	10		10	0	0	0	0
51N	2	14	059	2	H	12		12	0	0	0	0
51N	3	14	080	2	H	11		11	0	0	0	0
51N	4	14	081	2	H	10		10	0	0	0	0
51N	5	14	092	2	H	10		10	0	0	0	0
52N	1	11	134	4	L	4977		4976	3010	4927	4973	4976
52N	2	11	135	4	S	3327		3327	3327	3327	3327	3327
52N	3	11	155	4	L	9907		9905	1602	9905	9905	9905
52N	4	11	156	4	L	9960		9960	1634	9960	9960	9960
52N	5	11	157	4	S	9292		9291	2010	9291	9291	9291

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
53N	1	09	058	4	P	6096	6093	6093	533	4128	0	0
53N	2	09	059	4	L	6676		6676	530	4096	6599	6676
53N	3	09	135	2	H	6676		6676	193	1063	0	0
53N	4	09	136	2	L	5471		5471	313	2331	5470	5471
53N	5	09	137	2	L	4813		4813	298	2614	4812	4813
54N	1	16	178	2	L	1954		1789	24	337	1777	1789
54N	2	16	179	2	L	1954		1954	29	313	1953	1954
54N	3	16	182	2	L	1230		1153	26	295	1145	1153
54N	4	16	168	2	L	1941		1940	23	262	1928	1940
54N	5	16	180	2	L	1351		1348	22	333	1345	1348
55N	1	11	136	4	H	332		325	88	0	0	0
55N	2	11	137	4	H	303		282	0	0	0	0
55N	3	11	160	4	H	433		433	333	392	432	433
55N	4	11	159	4	H	431		431	330	394	431	431
55N	5	11	158	4	L	431		429	336	419	429	429
56N	1	14	060	2	L	3873		3873	830	3872	3873	3873
56N	2	14	061	2	L	3832		3832	808	3832	3832	3832
56N	3	14	083	2	S	5892		5892	745	5879	5890	5892
56N	4	14	084	2	S	7272		7272	734	7270	7272	7272
56N	5	14	085	2	S	3760		3760	715	3760	3760	3760
57N	1	13	042	2	L	2888		2888	2632	2806	2874	2888
57N	2	13	043	2	L	2528		2528	2390	2491	2510	2528
57N	3	13	018	2	S	2611		2611	2611	2611	2611	2611
57N	4	13	019	2	S	2451		2451	2451	2451	2451	2451
57N	5	13	020	2	S	2897		2896	2893	2896	2896	2896
58N	1	12	099	4	L	1534		1524	272	1506	1522	1524
58N	2	12	102	4	S	1733		1733	243	1726	1733	1733
58N	3	12	125	4	L	1684		1684	252	1674	1684	1684
58N	4	12	126	4	L	1677		1676	257	1673	1674	1676
58N	5	12	127	4	L	1735		1734	239	1734	1734	1734
59N	1	15	112	2	PS	1605	1462	1605	17	87	1605	1605
59N	2	15	113	2	P	1155	1146	1146	19	75	0	0
59N	3	15	107	2	S	1416		1416	19	86	1403	1416
59N	4	15	108	2	S	1613		1613	20	108	1607	1613
59N	5	15	109	2	L	1991		1590	19	113	1589	1590
60N	1	10	014	4	PL	8778	8631	8768	296	6272	8614	8768
60N	2	10	016	4	P	6482	6472	6472	321	4211	0	0
60N	3	10	042	4	L	8615		8614	296	3976	8414	8614
60N	4	10	043	4	L	8168		8167	318	5111	8045	8167
60N	5	10	044	4	L	8458		8458	305	4782	8407	8458
61N	1	12	104	4	S	2510		2513	2481	2518	2518	2518
61N	2	12	105	4	L	2344		2344	2342	2344	2344	2344
61N	3	12	050	4	S	2302		2302	2300	2302	2302	2302
61N	4	12	130	4	L	2115		2115	2114	2115	2115	2115

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
61N	5	12	129	4	L	2466		2466	2464	2466	2466	2466
62N	1	13	041	2	S	1612		1610	259	1610	1610	1610
62N	2	13	021	2	L	1908		1907	261	1907	1907	1907
62N	3	13	022	2	L	2556		2555	233	2547	2554	2555
62N	4	13	023	4	L	2934		2933	243	2933	2933	2933
62N	5	13	024	2	L	3029		3029	243	3029	3029	3029
63N	1	10	017	4	P	418	411	411	14	146	0	0
63N	2	10	023	4	PL	1041	793	1032	11	86	1022	1032
63N	3	10	046	4	L	1077		1075	10	46	1061	1075
63N	4	10	047	4	L	945		945	10	52	937	945
63N	5	10	048	4	L	1066		1066	12	129	1049	1060
64N	1	15	111	2	PL	6918	6917	6917	457	3327	6894	6917
64N	2	15	110	2	PL	6278	6136	6269	460	3877	6265	6269
64N	3	15	126	2	L	5856		5850	461	3801	5833	5850
64N	4	15	127	2	L	6660		6660	447	3733	6604	6660
64N	5	15	128	2	L	6072		6071	452	3118	6047	6071
65N	1	04	108	1	H	3157		3157	2355	2909	0	0
65N	2	04	109	1	L	5661		5660	2941	4415	5660	5660
65N	3	04	110	1	H	3157		3157	2356	2938	0	0
65N	4	04	133	1	L	4178		4165	2681	2873	4155	4155
65N	5	04	134	1	L	4560		4445	2872	3939	4462	4462
65N	6	04	135	1	R	2953		0	2682	0	0	0
65N	7	04	136	1	R	1504		0	0	0	0	0
65N	8	04	137	1	R	771		0	0	0	0	0
66N	1	04	111	1	D	13		13	0	0	0	0
66N	2	04	112	1	D	13		13	0	0	0	0
66N	3	04	113	1	D	13		13	0	0	0	0
66N	4	04	138	1	D	13		13	0	0	0	0
66N	5	04	139	1	D	13		13	0	0	0	0
66N	6	04	140	1	D	13		13	0	0	0	0
66N	7	04	141	1	D	13		13	0	0	0	0
66N	8	04	142	1	L	13		7	0	0	0	0
67N	1	04	114	1	H	8242		8242	7825	0	0	0
67N	2	04	115	1	H	9313		9313	0	0	0	0
67N	3	04	116	1	H	9313		9313	0	0	0	0
67N	4	04	151	1	L	14066		14066	14061	14063	14066	14066
67N	5	04	152	1	S	13662		13662	13662	13662	13662	13662
67N	6	04	153	1	R	6876		0	0	0	0	0
67N	7	04	154	1	R	4500		0	0	0	0	0
67N	8	04	155	1	R	2252		0	0	0	0	0
68N	1	04	117	1	PL	524	524	524	138	171	523	524
68N	2	04	118	1	PL	472	471	471	138	177	467	471
68N	3	04	119	1	PL	524	524	524	139	184	521	524
68N	4	04	156	1	L	955		951	140	185	949	951
68N	5	04	157	1	H	955		955	139	176	0	0

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
68N	6	04	158	1	R	300		0	145	176	0	0
68N	7	04	159	1	R	200		0	141	176	0	0
68N	8	04	160	1	R	100		0	0	0	0	0
69N	1	04	120	1	H	592		592	13	25	0	0
69N	2	04	121	1	L	592		183	10	13	29	183
69N	3	04	122	1	L	172		171	10	13	131	171
69N	4	04	161	1	L	148		127	13	17	87	127
69N	5	04	162	1	L	148		130	12	15	87	130
69N	6	04	163	1	L	148		140	12	16	85	140
69N	7	04	164	1	L	172		171	12	17	140	171
69N	8	04	165	1	R	502		0	12	17	208	0
70N	1	04	123	1	P	684	683	683	125	455	0	0
70N	2	04	126	1	P	1512	756	756	123	313	0	0
70N	3	04	127	1	P	684	653	653	125	392	0	0
70N	4	04	166	1	A	1512		0	194	450	0	0
70N	5	04	167	1	A	1512		0	181	579	0	0
70N	6	04	168	1	R	1201		0	198	539	0	0
70N	7	04	169	1	R	856		0	206	597	0	0
70N	8	04	170	1	R	401		0	214	0	0	0
71N	1	04	128	1	P	1631	1625	1625	204	0	0	0
71N	2	04	129	1	H	1638		1638	159	0	0	0
71N	3	04	130	1	P	1192	1185	1185	1152	0	0	0
71N	4	04	171	1	R	1422		0	258	0	0	0
71N	5	04	172	1	L	1415		1414	605	1414	1414	1414
71N	6	04	173	1	L	1357		1336	202	1356	1356	1356
71N	7	04	176	1	L	1540		1518	206	1518	1518	1518
71N	8	04	177	1	R	752		752	257	0	0	0
72N	1	04	131	1	P	1351	1304	1304	7	14	0	0
72N	2	04	132	1	P	1717	1646	1646	7	13	0	0
72N	3	04	179	1	H	1352		1352	7	14	0	0
72N	4	04	178	1	A	1717		0	7	14	1643	0
72N	5	04	191	1	A	1717		0	7	15	0	0
72N	6	04	192	1	R	149		0	7	14	0	0
72N	7	04	193	1	R	101		0	7	15	0	0
72N	8	04	194	1	R	50		0	7	15	0	0
73N	1	04	180	1	PL	2222	1938	2203	413	665	2193	2203
73N	2	04	181	1	H	3501		3501	335	388	0	0
73N	3	04	182	1	P	3501	3494	3494	322	382	0	0
73N	4	04	195	1	A	3501		0	321	380	0	0
73N	5	04	196	1	A	3501		0	319	382	0	0
73N	6	04	197	1	R	867		0	312	397	0	0
73N	7	04	198	1	R	624		0	305	380	0	0
73N	8	04	202	1	R	472		0	0	0	0	0
74N	1	04	183	1	P	1196	1196	1196	362	545	0	0
74N	2	04	185	1	P	1195	1195	1195	298	410	0	0
74N	3	04	187	1	P	1751	1648	1648	301	370	0	0

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
74N	4	04	203	1	[illegible]	[illegible]		1403	227	915	1603	1303
74N	5	04	204	1	L	1511		1510	154	39[illegible]	1610	1810
74N	6	04	205	1	R	375		0	196	0	0	0
74N	7	04	206	1	R	250		0	209	0	0	0
74N	8	04	207	1	R	141		0	0	0	0	0
75N	1	01	010	1	P	2505	2447	2447	394	930	0	0
75N	2	01	011	1	P	1835	1518	1918	748	861	0	0
75N	3	01	012	1	P	1555	1490	1490	385	706	0	0
75N	4	01	002	1	L	2560		2557	779	1000	2537	2557
75N	5	01	003	1	L	2486		2486	326	863	2486	2486
75N	6	01	004	1	R	2250		0	279	875	0	0
75N	7	01	005	1	R	1505		0	394	902	0	0
75N	8	01	006	1	R	750		0	527	0	0	0
76N	1	07	228	1	P	1202	1201	1201	349	0	0	0
76N	2	07	229	1	P	1669	1667	1667	353	692	0	0
76N	3	07	231	1	L	1115		1115	344	1027	1114	1115
76N	4	07	232	1	A	1669		0	315	591	0	0
76N	5	07	233	1	A	1669		0	305	384	0	0
76N	6	07	234	1	R	876		0	368	594	0	0
76N	7	07	235	1	R	623		0	299	587	0	0
76N	8	07	236	1	R	428		0	0	0	0	0
77N	1	02	026	1	H	1909		1909	387	715	0	0
77N	2	02	022	1	P	1909	1370	1370	620	705	0	0
77N	3	02	021	1	H	1909		1909	459	938	0	0
77N	4	02	014	1	H	1909		1909	389	939	0	0
77N	5	02	015	1	H	1909		1909	394	690	0	0
77N	6	02	016	1	R	1504		0	381	702	0	0
77N	7	02	017	1	R	1111		0	406	705	0	0
77N	8	02	018	1	R	605		0	372	0	0	0
78N	1	06	064	1	P	2267	2245	2245	602	921	0	0
78N	2	06	065	1	L	2365		2359	351	798	2359	2359
78N	3	06	066	1	L	2354		2347	365	806	2347	2347
78N	4	06	053	1	S	2354		2354	325	792	2354	2354
78N	5	06	054	1	S	2368		2368	323	741	2368	2368
78N	6	06	055	1	R	746		0	348	0	0	0
78N	7	06	057	1	R	509		0	350	0	0	0
78N	8	06	058	1	R	251		0	0	0	0	0
79N	1	03	037	1	P	2346	2158	2158	893	0	0	0
79N	2	03	036	1	S	3311		3310	629	3305	3310	3310
79N	3	03	035	1	P	1480	1460	1480	943	0	0	0
79N	4	03	027	1	S	3679		3679	692	3438	3679	3679
79N	5	03	028	1	A	3732		0	631	3669	0	0
79N	6	03	030	1	R	1463		0	715	0	0	0
79N	7	03	031	1	R	1112		0	673	0	0	0
79N	8	03	032	1	R	589		0	0	0	0	0
80N	1	05	049	1	P	3260	3223	3223	315	658	0	0

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAILURE MODE	FINAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
80N	2	05	051	1	[illegible]	232[illegible]		2297	235	565	2297	2297
80N	3	05	052	1	P	2329	2328	2328	342	690	0	0
80N	4	05	039	1	S	2320		2319	250	569	2319	2319
80N	5	05	040	1	S	2468		2467	257	566	2467	2467
80N	6	05	041	1	R	1425		0	262	575	0	0
80N	7	05	042	1	R	953		0	291	603	0	0
80N	8	05	043	1	R	511		0	295	0	0	0
81N	1	04	189	1	L	3014		3014	255	3014	0	3014
81N	2	04	190	1	R	1580	1579	1579	287	511	0	0
81N	3	04	224	1	P	1040	1039	1039	324	513	0	0
81N	4	04	208	1	A	3055		0	169	376	0	0
81N	5	04	209	1	A	3055		0	198	471	0	0
81N	6	04	210	1	R	1510		0	174	448	0	0
81N	7	04	211	1	R	1001		0	199	468	0	0
81N	8	04	212	1	R	502		0	237	0	0	0
82N	1	04	291	1	H	674		678	186	0	0	0
82N	2	04	292	1	H	678		678	182	0	0	0
82N	3	04	293	1	L	3803		3803	210	1706	3803	3803
82N	4	04	294	1	H	678		678	237	0	0	0
82N	5	04	295	1	H	678		678	222	0	0	0
83N	1	08	096	1								
83N*	2	08	099	1	L	7768						
83N	3	08	100	1								
83N	4	08	068	1								
83N	5	08	069	1								
83N	6	08	071	1	R	12758						
83N	7	08	072	1	R	8533						
83N	8	08	073	1	R	4255						
84N	1	08	103	1								
84N	2	08	104	1								
84N	3	08	105	1								
84N	4	08	081	1								
84N	5	08	082	1								
84N	6	08	083	1	R	20255						
84N	7	08	084	1	R	13674						
84N	8	08	085	1	R	6836						
85N	1	08	101	1								
85N	2	08	102	1								
85N	3	08	074	1								
85N	4	08	076	1								
85N	5	08	077	1								
85N	6	08	078	1								
85N	7	08	079	1								
85N	8	08	080	1	R	12054						
86N	1	08	106	1								
86N*	2	08	107	1	L	19547						

TABLE IV-9 CYCLE TEST RESULTS (continued)

PACK	CELL	GROUP	SERIAL	LOT	FAIL MODE	REMOVAL CYCLE	PRESSURE CYCLE	FAILURE CYCLE	CYCLES TO 1.1 VOLT	CYCLES TO 1.0 VOLT	CYCLES TO 0.5 VOLT	CYCLES TO 0.0 VOLT
86[illegible]	3	08	066	1								
86N	4	08	067	1								
86N	5	08	088	1								
86[illegible]	6	08	089	1	R	9799						
86[illegible]	7	08	090	1	R	6508						
86N	8	08	091	1	R	3262						
96[illegible]*	1	04	222	1	L	4158						
96[illegible]*	2	04	225	1	L	2678						
96[illegible]*	3	04	227	1	L	2704						
96[illegible]	4	04	297	1								

SECTION V

CHEMICAL AND PHYSICAL ANALYSES: TESTING AND RESULTS

One hundred fifty-seven cells were subjected to the chemical and physical analysis shown in Figure V-1. Seventy additional cells have received electrolyte and physical analysis only. Components of these cells have been stored so that the analysis may be completed in the future, if required funding is available. General trends that were observed are:

Positive plates thickness is expanding.

Negative plates show a decrease in capacity, probably due to cadmium hydroxide migration into the separator.

The negative charged active material increases.

Cadmium hydroxide migration into the separator is affecting the results of the separator patch tests, therefore, these results are to be accepted on a qualitative basis only.

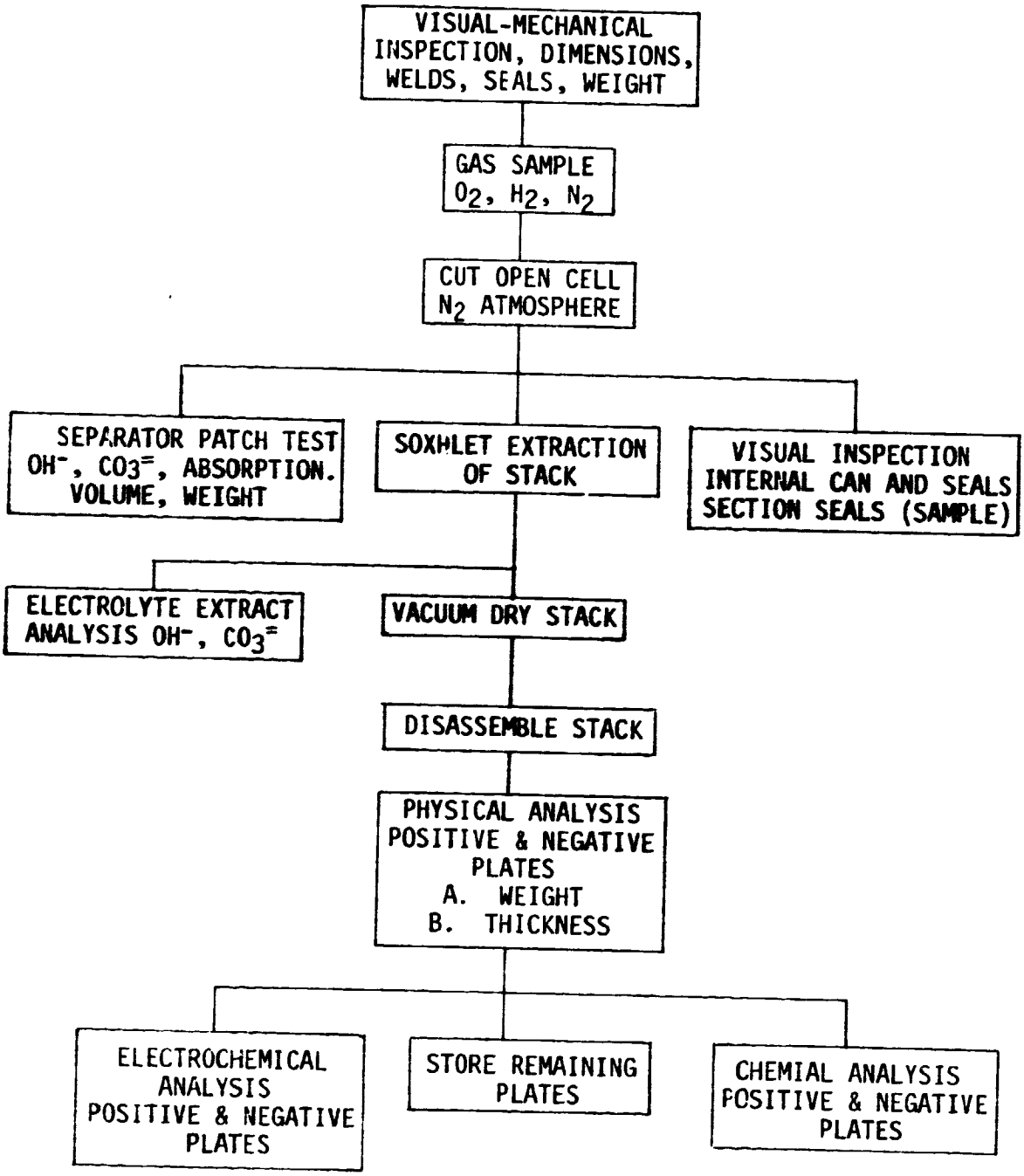
The gas analysis results are to be accepted on a qualitative basis, because of the elapsed time between removal from test and gas sampling.

These results provide information on the characteristics of failure, cell degradation and the effect of test parameters on the cells. This section presents a discussion of the analyses performed, changes in the schedule for analyses and the results of analyses.

A. ANALYSES PLANS AND MODIFICATIONS

The initial test plan called for chemical and physical analyses to be performed in accordance with Figure V-1 on 532 of the 546 total cells of the test program; 14 uncycled cells were to be stored at room ambient temperature for future reference. Analyses was well underway when it became apparent that the time required to complete the tests as defined would exceed the anticipated program completion date and the cost would exceed the available funding. Table V-1 presents a breakdown of the planned and actual testing performed, when the schedule was revised to:

FIGURE V-1 CHEMICAL AND PHYSICAL TESTS



Complete the analyses on all cells already in progress.

Suspend chemical analysis of positive plates. Review of the data indicated consistant results between the chemical and electrochemical analysis and duplication of tests did not warrent the cost of performing both tests. The electrochemical test would be run and the chemical analysis would be performed only if the electrochemical results indicated a change in the positive plate characteristics. All test plates would be retained so that the test could be run in the future, if desired.

Analyse two cells from each star point pack of those remaining.

Analyze one cell from each pack of those scheduled for removal from normal conditions.

Analyze one average cell and any early-failure cells from the fractional factorial points of the test plan.

This revision considerably changed the number of cells that were to be analyzed, but further changes were required. The separator patch test, chemical, electrochemical and gas analysis were deleted from the test plan for fractional factorial cells. The plates used to perform the chemical and electrochemical analysis were stored and can be run at a future date if deemed necessary.

TABLE V-1 CHEMICAL AND PHYSICAL ANALYSIS SCHEDULE

	PLANNED			ACTUAL		
	TOTAL NO. OF CELLS	SCHEDULE REMOVALS	CYCLE FAILURES	TOTAL NO. OF CELLS	SCHEDULED REMOVALS	CYCLE FAILURES
Star Point Packs	128	48	80	118	45	73
Center Point Packs	13	3	10	8	3	5
Factorial Packs	320	0	320	70*	--	70
Normal Packs	32	12	20	4**	4	--
Uncycled Cells	16	--	--	16***	--	--
Controlled Storage	23	23	--	15	15	--

* Electrolyte and Physical Analysis only
** Packs still cycling
*** One cell from each design variable group

B. TEST PROCEDURES

The procedures used in the performance of the chemical and physical testing are:

1. NASA/GSFC Document X-761-73-314 October 1973 "Procedure for Analysis of Nickel-Cadmium Cell Materials."

2. NASA/GSFC Document X-711-74-279 October 1974 "Procedure for Analysis of Nickel-Cadmium Materials".

3. NASA/GSFC Document X-711-75-317 December 1975 "Automated Calorimetric of Nickel-Cadmium Cells I. Electrolyte II. Positive plates".

A brief description of the test procedure is given in the following paragraphs.

C. TESTING AND RESULTS

1. Gas Analysis

Prior to opening the cell for failure analysis, a sample of gas from the cell was obtained and analyzed with a gas chromatograph to determine percentages of hydrogen, oxygen and nitrogen. Quantitative results are inconclusive as the analysis in most cases was not performed immediately after removal from test as the cell was allowed to "set" in a shorted condition for several weeks or months before being gas sampled. This setting time permitted the gas to recombine in the cell. For this reason and also consideration of funding and time, the gas sampling was discontinued in June 1978. It is recommended on future tests requiring gas analysis, a means be provided to obtain a gas sample without puncturing the case. Results of the gas analyses are shown in Table V-2.

2. Physical Plate Measurements

The physical characteristics (weight and thickness) of each plate in the cell were measured after extraction and vacuum drying. The individual plate thickness was determined by measuring the thickness in three locations (near the top, middle and bottom) of each plate. The average weight and thickness of the plates in the cell are shown in Table V-2. Analysis of the data indicated some variation in the physical characteristics of the plates within a cell and raised several questions: Does a variation exist between lots? Is there a variation in thickness between the top of the plate and the bottom? Were the plates ordered by physical characteristics? Does the positive plate become thicker with life? These questions were investigated and the results are discussed in Section VI. In accordance with the test procedures, each plate was identified for a particular analysis as shown in Table V-3.

SUMMARY OF CHEMICAL AND PHYSICAL ANALYSIS

NOMENCLATURE FOR

TABLE V-2 PLATE ANALYSIS

IDENTIFICATION

Pack No. - Identifies the test parameters of Figure IV-1 and Table IV-1.

Cell ID - Cell identification data:
- S/N - serial number
- L - Lot
- GRP - design group
- POS - position in pack

Removal Cycle - Cycle at which the cell was removed from test.

GAS SAMPLING - RESULTS OF THE GAS SAMPLING:

- H_2 - Percentage Hydrogen
- O_2 - Percentage Oxygen
- N_2 - Percent Nitrogen

CHEMICAL - CHEMICAL ANALYSIS OF PLATES

Cadmium - Negative plate analysis.

$CD(OH)_2$ - Cadmium Hydroxide, calculated discharged active material in grams (G) and converted to equivalent ampere-hours (AH).

CD - Cadmium, calculated charged active material as grams (G) of $Cd(OH)_2$ and converted to equivalent ampere-hours (AH).

Nickel - Positive plate analysis.

$NI(OH)_2$ - Nickel-hydroxide, calculate discharged active material in grams (G) and converted to equivalent ampere-hours (AH).

NI - Metallic nickel, calculated metallic nickel in grams (G).

ELECTROCHEMICAL - RESULTS OF ELECTROCHEMICAL TESTING

Capacity - Capacity in ampere-hours of the negative (NEG) and positive (POS) plate.

Residual - Charged capacity of negative (NEG) plates at start of test.

Utilization Percentage - Electrochemical capacity divided by the chemical capacity times 100.

DATE= 02/28/1.

TABLE V-2 PLATE ANALYSIS

--IDENTIFICATION--			--GAS SAMPLING--				---CHEMICAL---							--ELECTROCHEMICAL---			UTILIZATION PERCENTAGE	
							---CADMIUM---				---NICKEL---			CAPACITY		RESIDUAL		
PACK NO.	CELL ID S/N-L-GRP-POS	REMOVAL CYCLE	PERCENTAGE O2	O3	N2		CD(OH)2 (G)	CD (AH)	CD (G)	CD (AH)	NI(OH)2 (G)	NI (AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
	001 1 01	00000					4.36	1.60	.09	.03	3.27	.94	.94	.95	.69	0.00	58.1	72.8
	013 1 02	00000					4.36	1.59	.08	.03	3.16	.91	.94	.90	.66	0.00	55.2	74.7
	026 2 13	00000					4.38	1.60	.10	.04	3.57	1.03	.75	.78	.80	.00	47.7	77.8
	029 1 03	00000					4.38	1.60	.08	.03	2.76	.80	1.01	.90	.72	0.00	55.3	89.7
	038 1 05	00000					4.44	1.63	.13	.05	3.28	.92	.97	.88	.73	.01	53.5	79.0
	051 4 10	00000									3.74	1.08	1.04	1.19	.85	.05		78.3
	056 1 06	00000					4.38	1.60	.10	.04	3.29	.95	.90	1.07	.76	.01	65.0	73.2
	067 1 08	00000												1.05	.68	0.00	0.0	0.0
	071 4 09	00000												.88	.84	.06	0.0	0.0
	087 2 14	00000					4.46	1.63	.06	.02	3.39	.98	.88	.87	.83	.01	52.5	84.1
	130 2 15	00000					4.36	1.59	.17	.06	3.61	1.04	.94	1.22	.84	.07	73.8	80.3
	164 4 11	00000					4.45	1.63	.13	.05	3.46	1.04	.97	1.20	.82	.05	71.5	77.2
	168 4 12	00000					4.40	1.61	.17	.06	3.72	1.08	1.06	1.28	.82	.09	76.7	74.2
	181 2 16	00000					4.67	1.71	.19	.07				1.29	.78	.07	72.3	0.0
	213 1 04	00000					4.41	1.61	.12	.06	2.89	.86	.98	1.02	.71	0.00	61.4	84.7
	230 1 07	00000					4.36	1.60	.11	.06	3.09	.89	.96	1.04	.69	0.00	63.6	77.0
1N	138 2 09	3 10914																
2N	164 2 16	2 00948																
3N	091 4 11	1 01471																
4N	063 2 14	4 03014	6.3	.3	95.2		3.15	1.15	.70	.26								
6N	056 4 09	1 00601	1.6	.3	40.3		3.15	1.15	.50	.21								
7N	047 2 14	1 03136																
8N	139 4 11	2 02544	24.3	2.5	91.7		2.70	.99	1.08	.39								
8N	162 4 11	4 04099	8.2	2.0	98.0		3.41	1.32	.96	.20								
9N	019 4 12	2 15516																
10N	004 2 13	4 00032					3.99	1.46	.36	.12	3.56	1.03	.85	.99	.88	.07	62.4	85.3
11N	020 4 12	5 02403																
12N	088 2 15	3 02037	3.0	1.5	92.7		2.98	1.09	.44	.24								
13N	007 2 13	4 13819																
13N	036 2 13	2 04258																
14N	112 4 12	5 00041																
15N	091 2 15	4 02707	7.3	1.1	77.3		3.22	1.18	.72	.24	3.42	1.11	1.02	1.17	.88	.23	0.0	79.3

DATE= 02/28/73

TABLE V-2 PLATE ANALYSIS (continued)

PAGE 2

--IDENTIFICATION--					--GAS SAMPLING--			---CHEMICAL---							--ELECTROCHEMICAL---			UTILIZATION PERCENTAGE	
								---CADMIUM---				---NICKEL---			CAPACITY		RESIDUAL		
PACK NO.	CELL ID S/N-L-GRP-POS			REMOVAL CYCLE	PERCENTAGE H2	O2	N2	CD(OH)2 (G)	CD(OH)2 (AH)	CD (G)	CD (AH)	NI(OH)2 (G)	NI(OH)2 (AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
16N	027 4 10	4		06253															
16N	028 4 10	5		05653	7.8	0.0	92.5	2.64	.97	.88	.32								
17N	144 4 11	4		01265	14.7	0.0	85.0	3.57	1.31	.42	.15								
18N	069 2 14	4		05221															
18N	070 2 14	3		10493															
19N	077 4 09	4		02344	0.0	1.7	92.2	3.64	1.33	.46	.17								
20N	147 2 16	3		14366															
20N	167 2 16	1		06178															
21N	073 2 14	5		00420															
22N	098 4 11	2		02722															
23N	152 2 16	5		04585	7.8	0.0	89.4	2.93	1.07	1.08	.40								
24N	079 4 09	3		01944															
26N	095 2 15	4		11064															
27N	113 4 12	3		02537	0.0	.8	89.5	3.43	1.26	.42	.15								
28N	027 2 13	1		02033	0.0	7.8	59.0	4.06	1.49	.12	.04								
29N	098 2 15	4		00034								3.76	1.09	.81	.72	.92	.09		84.4
30N	009 4 10	2		03570															
30N	033 4 10	4		05621	20.7	3.2	80.3	3.83	1.40	.41	.15								
30N	034 4 10	5		07459															
31N	010 2 13	4		04449	0.0	0.0	58.5	3.10	1.13	.50	.18								
32N	117 4 12	4		02933															
34N	150 4 11	4		02366	21.3	.8	95.0	3.22	1.18	1.08	.39								
35N	154 2 16	4		04045	0.0	3.7	99.4	3.20	1.17	.50	.18								
35N	172 2 16	1		00429				3.57	1.31	.81	.30	3.71	1.07	.85	.97	.79	.17	60.3	73.9
36N	082 4 09	5		01328	23.0	.9	74.3	3.49	1.28	.63	.23								
37N	152 4 11	3		01215	17.2	9.2	75.0												

DATE= 12/29/74

TABLE V-2 PLATE ANALYSIS (continued)

--IDENTIFICATION--					--GAS SAMPLING--			----------CHEMICAL----------						--ELECTROCHEMICAL---			UTILIZATION PERCENTAGE	
								---------CADMIUM---------				------NICKEL------		CAPACITY		RESIDUAL		
PACK NO.	CELL ID SYN-L-ROP-POS			REMOVAL CYCLE	PERCENTAGE H3	H2	N2	CD(OH)2 (G)	CD (AH)	CD (G)	CD (AH)	NI(OH)2 (G)	NI (AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
38N	077	2 14	3	06172	3.0	.3	91.3	3.74	1.37	.49	.18								
39N	085	4 09	3	09640															
39N	086	4 09	4	05327	0.0	1.7	88.5	3.31	1.17	.44	.24								
40N	156	2 14	3	00590	5.5	0.0	91.3	2.71	.99	1.01	.37								
41N	102	2 15	4	03405	0.0	3.0	99.5	3.78	1.38	.56	.21								
42N	036	4 10	4	00958															
43N	031	2 13	1	10222															
44N	120	4 12	4	02540															
45N	040	4 10	5	01537	2.7	9.8	79.7	3.76	1.38	.20	.07								
46N	104	2 15	3	02973	0.0	.6	96.3	2.93	1.06	1.09	.40								
47N	123	4 12	4	07776															
48N	015	2 13	3	00756	10.7	1.8	95.2	3.77	1.38	.36	.13								
49N	177	2 16	2	01657															
50N	069	4 09	2	01578	63.0	1.0	78.6	3.86	1.41	.49	.18								
52N	156	4 11	4	09960															
53N	137	2 09	5	04813	0.0	.7	86.8												
54N	168	2 16	4	01941	15.5	1.0	57.3	3.93	1.44	.43	.14								
56N	085	2 14	5	03760	0.0	14.0	82.0	3.52	1.29	.19	.07								
57N	019	2 13	3	02451	5.3	6.0	89.0	2.40	.88	.95	.35								
58N	099	4 12	1	01534	7.0	1.2	92.8	3.06	1.12	.95	.35								
59N	105	2 15	4	01613															
60N	042	4 10	3	08615															
61N	129	4 12	4	02115	0.0	.5	93.1	3.58	1.31	.30	.11								
62N	022	2 13	3	03556	0.0	2.3	92.1	3.60	1.32	.30	.11								

DATE= 02/28/79

TABLE V-2 PLATE ANALYSIS (continued)

--IDENTIFICATION--			--GAS SAMPLING--				CHEMICAL							--ELECTROCHEMICAL--			UTILIZATION PERCENTAGE	
							CADMIUM				NICKEL			CAPACITY		RESIDUAL		
PACK NO.	CELL I.D. S/N-L-GRP-POS	REMOVAL CYCLE	PERCENTAGE O2	PERCENTAGE H2	PERCENTAGE N2	CD(OH)2 (G)	CD(OH)2 (AH)	CD (G)	CD (AH)	NI(OH)2 (G)	NI(OH)2 (AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
63N	047 4 10 4	00945	20.3	1.0	83.3	3.10	1.13	1.17	.43								
65N	108 1 04 1	03157															
65N	109 1 04 2	05641				3.42	1.25	.65	.24	3.43	.99	.94	.98	.73	.09	65.4	73.3
65N	110 1 04 3	03157				3.44	1.33	.34	.12	3.41	.98	.95	.91	.75	.01	62.2	74.0
65N	133 1 04 4	04178				3.37	1.24	.60	.22				1.03	.76	.22	70.7	
65N	134 1 04 5	04560				3.68	1.35	.38	.14				.97	.79	.12	65.0	
65N	135 1 04 6	02953				3.62	1.32	.32	.12				.97	.78	.08	67.5	
65N	136 1 04 7	01504				4.07	1.49	.24	.09	3.36	.97	.87	.96	.77	0.00	60.5	79.3
65N	137 1 04 8	00771				3.82	1.40	.23	.09	3.33	.96	.92	.95	.70	.09	63.8	73.1
						3.71	1.36	.51	.19	3.08	.89	1.12	.86	.73	.14	55.7	82.4
66N	142 1 04 8	00013	0.0	20.5	78.0	4.03	1.48	.28	.10	3.52	1.02	.88	.74	.81	.15	46.7	79.5
67N	114 1 04 1	08243															
67N	115 1 04 2	09313				2.95	1.04	1.11	.41	3.40	.98	.97	.86	.65	.26	59.4	65.6
67N	116 1 04 3	09313															
67N	151 1 04 4	14064															
67N	152 1 04 5	13662				3.10	1.13	.55	.20	3.33	.96	.96	.97	.66	.44	72.6	68.8
67N	153 1 04 6	06876				3.13	1.15	.59	.22	3.41	.99	.95					
67N	154 1 04 7	04500				3.74	1.38	.34	.13	3.46	1.00	.85	.92	.70	.20	60.6	69.5
67N	155 1 04 8	02253				3.38	1.24	.84	.31	4.06	1.17	.96	1.17	.78	.19	75.6	66.4
						3.72	1.36	.42	.15	2.56	.74	.79	1.02	.71	.13	66.9	95.5
68N	117 1 04 1	00524	73.0	6.5	17.5	3.12	1.14	.92	.33	3.59	1.04	.86	1.02	.79	.07	69.3	76.1
68N	118 1 04 2	00473	48.5	4.5	44.5	2.92	1.07	1.11	.40	3.74	1.08	.90	.73	.86	.05	49.6	79.4
68N	119 1 04 3	00524	14.5	5.5	80.0	3.52	1.29	.73	.27	3.58	1.03	.88	.66	.90	.04	42.3	86.7
68N	156 1 04 4	00955	15.5	14.5	70.5	3.04	1.11	1.07	.39	3.54	1.02	.77	.40	.90	.05	26.3	88.3
68N	157 1 04 5	00955	65.0	9.5	25.0	3.23	1.18	.74	.27	3.86	1.12	.78	.95	.86	.14	65.3	77.2
68N	158 1 04 6	00300	9.0	4.5	81.5	2.79	1.02	1.08	.39	3.62	1.05	.90	.96	.82	.17	67.5	77.8
68N	159 1 04 7	00300	19.0	11.0	65.0	3.40	1.25	.41	.15	3.72	1.07	.80	1.06	.79	.10	75.8	73.7
68N	160 1 04 8	00100	18.5	10.5	69.5	3.39	1.24	.81	.30	3.37	.97	.93	.98	.77	.10	63.8	79.4
69N	120 1 04 1	00592															
69N	121 1 04 2	00592				3.30	1.21	.79	.29	3.57	1.03	.88	1.04	.90	.07	69.1	87.0
69N	122 1 04 3	00172				3.73	1.37	.46	.17	3.38	.98	.91	.99	.85	.05	64.6	86.8
69N	161 1 04 4	00148	65.5	11.0	23.0	4.12	1.51	.30	.11	3.33	.96	.98	1.07	.69	.04	66.2	71.1
69N	162 1 04 5	00148	62.0	12.0	26.0	2.97	1.09	.49	.18	3.22	.93	.94	1.02	.74	0.00	80.6	79.8
69N	163 1 04 6	00148	51.0	10.0	45.0	3.47	1.34	.57	.21	3.23	.93	.9[illegible]	.92	.76	0.00	59.1	81.7
69N	164 1 04 7	00173	50.5	9.5	46.0	3.71	1.36	.47	.17	3.19	.92	.90	.77	.75	0.00	50.2	81.1
69N	165 1 04 8	00573				3.82	1.40	.45	.17	3.64	1.05	1.00	1.10	.77	.03	70.2	73.1
70N	123 1 04 1	00684															
70N	124 1 04 2	01512				2.50	.92	1.35	.49	4.11	1.19	.91	.66	.86	.26	46.7	71.9
70N	127 1 04 3	00684	8.1	37.4	62.3	2.44	.89	1.42	.52	3.48	1.06	.88	.58	.82	.22	40.9	76.7
70N	166 1 04 4	01512	71.0	2.5	26.0	3.01	1.10	1.23	.45				.88	.77	.17	56.6	
70N	167 1 04 5	01512	75.5	2.0	22.5	3.00	1.10	.78	.29	3.54	1.02	.87	.74	.83	.00	24.3	81.3
70N	168 1 04 6	01201	76.5	3.5	19.0	2.93	1.07	.71	.26	3.40	.98	.88	.77	.77	.01	57.9	78.3
						3.00	1.10	1.04	.38	2.98	.86	.76	.88	.79	.06	59.7	91.7

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TABLE V-2 PLATE ANALYSIS (continued)

--IDENTIFICATION--				--GAS SAMPLING--				CHEMICAL							--ELECTROCHEMICAL--			UTILIZATION PERCENTAGE	
								CADMIUM				NICKEL			CAPACITY		RESIDUAL		
PACK NO.	SAMPLE	CELL	CYCLE	H2	O2	N2		CD(OH)2 (G)	CD (AH)	CD (G)	CD (AH)	NI(OH)2 (G)	NI (AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
70N	169	1 04	7	00856	10.5	10.5	77.5	3.26	1.19	1.09	.40	3.31	.96	.88	.93	.74	.08	58.5	77.3
70N	170	1 04	8	00461	9.5	5.0	81.5	3.65	1.34	.72	.26	3.22	.93	.91	.82	.76	.12	51.3	81.2
71N	128	1 04	1	01631				1.80	.66	1.58	.58	3.67	1.06	.83	.91	.73	.34	73.3	68.8
71N	129	1 04	2	01638				1.65	.60	1.60	.59	3.57	1.03	.83	.82	.79	.33	69.2	76.9
71N	130	1 04	3	01193				2.23	.82	1.48	.54	3.68	1.06	.84	.93	.76	.37	68.6	71.6
71N	171	1 04	4	01432				2.74	1.00	1.03	.38	3.65	1.06	.88	.87	.83	.15	62.9	78.2
71N	172	1 04	5	01415				2.07	.76	1.51	.55	3.64	1.05	.94	.83	.82	.42	63.4	77.8
71N	173	1 04	6	01357				2.30	.84	1.40	.51	3.55	1.02	.88	.79	.79	.23	58.0	75.9
71N	176	1 04	7	01540				2.85	1.04	.79	.29	3.75	1.08	.85	.83	.81	.23	62.2	74.5
71N	177	1 04	8	00752				3.40	1.24	.77	.28	3.41	.98	1.03	.84	.77	.21	55.0	77.9
72N	131	1 04	1	01351	82.0	2.0	15.5	2.59	.95	.86	.32	3.50	1.01	.88	.84	.81	.08	66.5	80.2
72N	132	1 04	2	01717	73.5	5.0	20.5	2.65	.97	1.49	.55	3.66	1.06	.77	.76	.86	.09	50.1	80.8
72N	178	1 04	4	01717	62.0	15.0	22.0	2.39	.88	1.34	.49	3.74	1.08	.83	.62	.84	.21	45.2	77.7
72N	179	1 04	3	01352	21.0	11.5	67.0	2.31	1.07	1.10	.40	3.47	1.00	.94	.69	.78	.12	47.1	77.4
72N	191	1 04	5	01717	71.5	0.0	23.0	2.87	1.05	1.09	.40	3.76	1.09	.86	.63	.83	.14	43.7	74.6
72N	192	1 04	6	00149	69.0	2.0	28.0	4.02	1.47	.39	.14	3.17	.92	.94	.57	.80	.00	35.3	87.2
72N	193	1 04	7	00101	81.0	3.0	15.6	4.07	1.49	.12	.05	3.12	.90	.86	.87	.74	.01	56.3	82.1
72N	194	1 04	8	00050	54.0	3.0	43.0	3.91	1.43	.24	.09	3.20	.92	.87	.94	.86	0.00	61.6	92.5
73N	180	1 04	1	03222				2.69	.99	1.35	.49	3.44	1.00	.84	.92	.76	.14	62.0	76.7
73N	181	1 04	2	03501				2.06	.75	1.47	.61	3.66	1.06	.87	.81	.78	.38	59.4	74.0
73N	182	1 04	3	03501				2.14	.78	1.71	.63	4.90	1.42	.65	.85	.83	.21	60.4	58.7
73N	195	1 04	4	03501				2.47	.91	1.31	.48	4.06	1.17	.68	.92	.87	.28	66.4	74.2
73N	196	1 04	5	03501				2.58	.95	1.17	.43	3.75	1.08	.87	.81	.83	.27	59.0	76.7
73N	197	1 04	6	00867				2.99	1.09	1.02	.37	3.49	1.07	.87	.94	.77	.26	64.0	72.1
73N	198	1 04	7	00624				3.85	1.41	.43	.16	3.43	1.05	.90	.86	.77	.12	54.6	73.1
73N	202	1 04	8	00472	25.0	5.0	70.0	2.83	1.04	1.37	.50	3.54	1.02	.87	.93	.77	.31	60.5	75.5
74N	183	1 04	1	01196				3.41	1.25	1.01	.37	3.60	1.06	.63	.86	.62	.09	53.3	59.8
74N	185	1 04	2	01195				1.31	.48	1.34	.49	3.20	.93	.94	.81	.76	.12	83.7	82.0
74N	187	1 04	3	01751				2.45	.90	1.60	.59	3.71	1.07	.85	.95	.74	.30	64.0	69.1
74N	203	1 04	4	01808				2.72	1.00	1.08	.40	3.30	.95	.93	.42	.80	.20	30.1	84.1
74N	204	1 04	5	01811				2.89	1.06	1.05	.38	3.51	1.01	.83	.48	.81	.16	33.2	80.0
74N	205	1 04	6	00375				3.85	1.41	.36	.13	3.44	.99	.94	.83	.76	.00	53.6	76.3
74N	206	1 04	7	00350				3.67	1.34	.56	.20	3.39	.98	.93	1.08	.81	.14	69.9	82.2
74N	207	1 04	8	00141				3.50	1.28	.98	.36	3.02	.87	.94	.76	.78	.06	46.1	88.8
75N	002	1 01	4	02560				3.12	1.14	.97	.35	3.49	1.01	.86	.96	.89	.28	64.3	88.2
75N	003	1 01	5	02486				2.43	.89	1.44	.53	3.42	.99	.83	1.10	.86	.47	77.5	86.5
75N	004	1 01	6	02353				3.16	1.16	1.11	.40	3.75	1.08	.77	.94	.82	.29	53.7	75.5
75N	005	1 01	7	01505				3.16	1.16	.99	.36	3.46	1.00	.93	.90	.79	.12	59.1	79.0
75N	006	1 01	8	00750								3.30	.96	.93	1.12	.77	.30		81.0
75N	010	1 01	1	02505				2.42	.89	1.50	.55	3.97	1.15	.74	.72	.87	.42	50.0	75.9
75N	011	1 01	2	01835				2.37	.87	1.77	.65	3.68	1.06	.82	.76	.83	.46	49.9	77.9

TABLE V-2 PLATE ANALYSIS (continued)

--IDENTIFICATION--				--GAS SAMPLING--			--CHEMICAL--							--ELECTROCHEMICAL--			UTILIZATION PERCENTAGE	
							--CADMIUM--				--NICKEL--			CAPACITY		RESIDUAL		
PACK NO.	CELL ID S/N-L-GRP-POS		REMOVAL CYCLE	PERCENTAGE H2	O2	N2	CD(OH)2 (G)	(AH)	CD (G)	(AH)	NI(OH)2 (G)	(AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
75N	012 1 01	3	01535				2.90	1.06	1.27	.46	3.65	1.05	.86	.92	.83	.30	60.0	78.5
76N	228 1 07	1	01202				2.68	.98	1.14	.43	3.39	.98	.92	.93	.80	.13	66.4	81.7
76N	229 1 07	2	01663				2.54	.93	1.42	.52	3.89	1.13	.76	.82	.84	.13	56.5	74.3
76N	231 1 07	3	01115				2.93	1.04	1.17	.43	3.72	1.08	.78	.91	.88	.24	62.3	81.5
76N	232 1 07	4	01669	54.0	6.5	38.5	2.39	.88	1.45	.53	3.47	1.00	.86	.69		.16	48.7	
76N	233 1 07	5	01669				2.98	1.09	1.05	.38	4.59	1.33	.76	.88	.82	.13	59.8	61.6
76N	234 1 07	6	00876				2.68	.98	1.24	.45	4.28	1.24	.81	.81	.83	.15	56.6	67.0
76N	235 1 07	7	00623				3.62	1.32	.62	.23	4.38	1.27	.85	.94	.87	.11	60.8	68.7
76N	236 1 07	8	00428				3.91	1.43	.29	.11	3.99	1.15	.91	1.00	.83	.06	64.8	72.1
77N	014 1 02	4	01909	2.0	18.0	80.0	3.71	1.36	.38	.14	3.72	1.07	.86	.96	.85	.04	63.9	79.4
77N	015 1 02	5	01909	0.0	17.0	81.5	3.20	1.17	.24	.09	2.58	.75	1.15	.97	.80	.02	76.7	106.7
77N	016 1 02	6	01504				3.45	1.26	.52	.19	3.53	1.02	.82	1.01	.95	.23	69.5	93.0
77N	017 1 02	7	01111				3.46	1.27	.66	.24	3.58	1.04	.90	1.09	.92	.29	71.9	88.5
77N	018 1 02	8	00615				3.18	1.16	.98	.36	3.59	1.04	.89	.98	.89	.17	64.4	85.7
77N	021 1 02	3	01909	5.0	10.0	83.5	3.36	1.23	.75	.27	3.37	.97	.92	1.01	.79	.03	67.1	80.6
77N	022 1 02	2	01909	3.5	12.0	79.5	3.70	1.35	.47	.17	3.50	1.01	.92	1.05	.88	.08	68.5	86.9
77N	026 1 02	1	01909	12.0	0.0	82.0	3.71	1.36	.52	.19	3.71	1.07	.90	.78	.73	.06	50.2	67.6
78N	053 1 06	4	02354				3.02	1.10	.97	.35	3.49	1.01	1.98	.71	.71	.25	48.4	70.7
78N	054 1 06	5	02368				2.79	1.02	1.10	.40	3.88	1.12	.73	.92	.82	.27	64.6	73.1
78N	055 1 06	6	00748				3.68	1.35	.63	.23	3.37	.97	.97	.88	.75	.01	55.9	77.2
78N	057 1 06	7	00509				3.85	1.41	.57	.21	3.26	.94	.96	.75	.75	.13	46.2	79.3
78N	058 1 06	8	00251				3.79	1.39	.71	.26	3.14	.91	.94	.96	.73	.12	58.3	80.1
78N	064 1 06	1	02247				2.04	.75	1.48	.54	3.37	.97	.89	1.04	.59	.28	80.7	60.9
78N	065 1 06	2	02365				3.27	1.20	.76	.28	3.65	1.06	.84	.79	.76	.09	53.6	71.6
78N	066 1 06	3	02354				3.11	1.14	.85	.31	3.74	1.08	.78	.98	.75	.18	67.4	69.1
79N	027 1 03	4	03679	18.3	5.4	78.3	3.64	1.33	.59	.21				.83	.78	.24	53.6	
79N	028 1 03	5	03732				3.66	1.34	.42	.15	3.76	1.09	.73	.73	.81	.02	49.1	74.7
79N	030 1 03	6	01463				3.44	1.26	.75	.27	3.29	.95	.94	.82	.87	.11	53.3	91.0
79N	031 1 03	7	01113				3.02	1.11	.92	.34	3.56	1.02	.87	.99	.79	.17	68.5	77.5
79N	032 1 03	8	00580				4.09	1.50	.22	.08	3.55	1.03	.83	.79	.81	.02	49.9	79.3
79N	035 1 03	3	01480	73.5	5.0	21.5	3.30	1.21	.80	.29	3.72	1.07	.81	.91	.82	.17	60.4	76.4
79N	036 1 03	2	03311	63.5	11.5	25.0	3.14	1.15	.98	.36	3.69	1.07	.71	1.00	.84	.18	65.8	78.8
79N	037 1 03	1	02346	59.0	3.0	35.0	2.60	.95	1.44	.53	3.79	1.09	.86	.66	.81	.21	44.7	74.1
80N	039 1 05	4	02320	7.0	10.0	83.0	2.89	1.06	1.07	.39	3.48	1.00	.78	.68	.80	.04	46.8	79.3
80N	040 1 05	5	02469	43.5	2.0	49.5	3.11	1.14	.82	.30	3.26	.94	.89	.86	.83	.13	59.5	88.4
80N	041 1 05	6	01425	35.5	3.5	59.5	3.65	1.34	.44	.16	3.36	.97	.87	1.01	.86	.10	67.4	88.6
80N	042 1 05	7	00953	67.0	10.5	22.0	3.59	1.32	.69	.25	3.35	.97	.92	.92	.78	.20	58.5	79.9
80N	043 1 05	8	00511	9.0	12.5	78.5	3.80	1.39	.36	.13	3.55	1.03	.94	1.00	.74	.12	65.4	72.5
80N	049 1 05	1	03360	9.8	4.5	71.0	3.02	1.11	1.11	.41	3.35	.97	.86	.81	.75	.30	53.2	77.1
80N	051 1 05	2	02320	59.5	4.0	35.0	3.37	1.23	1.51	.55	3.33	.96	.83	.79		.04	44.2	
80N	052 1 05	3	02329	81.5	6.0	22.0	3.18	1.16	.89	.32	3.45	1.00	.89	.82	.81	.12	55.3	80.8

TABLE V-2 PLATE ANALYSIS (continued)

--IDENTIFICATION--					--GAS SAMPLING--			--CHEMICAL--							--ELECTROCHEMICAL--				
								--CADMIUM--				--NICKEL--			CAPACITY		RESIDUAL	UTILIZATION PERCENTAGE	
PACK NO.	CELL ID S/N-L-GRP-POS			REMOVAL CYCLE	PERCENTAGE H2	O2	N2	CD(OH)2 (G)	(AH)	CD (G)	(AH)	NI(OH)2 (G)	(AH)	NI (G)	NEG (AH)	POS (AH)	NEG (AH)	NEG	POS
R1N	189 1 04		1	03014				3.11	1.14	.99	.34				.79	.63	.22	52.8	
R1N	190 1 04		2	01590	69.5	5.5	23.5	3.71	1.36	.49	.18	3.46	1.00	.95	.74	.72	.00	48.2	72.4
R1N	208 1 04		4	03055	5.0	.1	91.1	2.73	1.00	1.40	.51				.86	.58	.31	56.8	
R1N	209 1 04		5	0 055	17.5	0.0	74.8	2.92	1.07	1.25	.46				.74	.64	.27	48.6	
R1N	210 1 04		6	01510	7.5	15.0	73.0	3.23	1.18	.89	.33	3.42	.99	.91	.91	.75	.12	60.1	75.6
R1N	211 1 04		7	01001	6.5	11.5	80.0	3.53	1.29	.59	.22	3.40	.98	.86	1.03	.75	.08	68.5	76.5
R1N	212 1 04		8	00502	12.5	2.9	61.8	3.81	1.39	.46	.17	3.24	.94	.91	.96	.68	.17	61.5	72.5
R1N	224 1 04		3	01040	69.5	0.0	29.0	2.83	1.04	1.46	.54	3.42	.99	.96	.77	.65	.05	48.6	65.2
R2N	291 1 04		1	00678				4.12	1.51	.06	.02	3.50	1.01	.92	1.09	.73	0.00	71.5	71.6
R2N	292 1 04		2	00678				4.13	1.51	.07	.03	3.40	.98	.92	1.11	.88	.01	71.9	89.8
R2N	293 1 04		3	03803															
R2N	294 1 04		4	00678															
R2N	295 1 04		5	00678															
R3N	071 1 08		6	00000				4.23	1.55	.08	.03	3.39	.98	.90	.99	.84	.00	62.8	86.0
R3N	073 1 08		8	00000															
R3N	099 1 08		2	00000															
R4N	086 1 09		7	00000															
R6N	089 1 08		6	00000															
R7N	219 1 04		1	00000	0.0	20.0	79.0	3.51	1.28	.08	.03	3.24	.94	.97	.97	.73	.02	73.8	77.5
R7N	220 1 04		2	00000	0.0	20.0	75.5	4.22	1.55	.05	.02	3.11	.90	.96	.81	.81	.01	52.0	89.7
R7N	221 1 04		3	00000								3.21	.93	.94	1.14	.73	.00		78.1
R8N	216 1 01		1	00000				4.43	1.62	.14	.05	3.16	.91	.97	1.05	.66	.00	62.6	72.6
R8N	217 1 01		2	00000				4.46	1.63	.10	.04				1.01	.68	0.00	60.5	
R8N	218 1 01		3	00000				4.18	1.53	.08	.03				1.09	.70	0.00	70.1	
90N	237 1 01		1	00000				4.23	1.55	.13	.05	3.24	.94	.95	1.14	.76	.01	71.7	80.7
90N	238 1 01		2	00000				4.21	1.54	.11	.04	3.29	.95	.87	1.08	.77	.01	68.6	81.3
90N	239 1 01		3	00000				4.11	1.51	.17	.06	3.65	1.06	.76	1.10	.78	.01	69.9	73.5
91N	059 1 06		1	00000				4.23	1.55	.15	.06	3.08	.89	.99	1.12	.64	.06	69.9	71.3
91N	060 1 06		2	00000				4.26	1.56	.19	.07				1.03	.64	.06	63.2	
91N	061 1 06		3	00000				4.40	1.61	.19	.07				1.09	.72	.05	64.5	
92N	044 1 05		1	00000				4.45	1.63	.15	.05	3.43	.99	1.03	1.12	.70	.05	66.4	70.4
92N	045 1 05		2	00000				4.05	1.48	.22	.08	3.29	.95	1.02	1.10	.73	.09	70.4	76.7
92N	046 1 05		3	00000				4.34	1.59	.09	.03	3.21	.93	.98	1.09	.75	.11	67.5	80.3

TABLE V-3 IDENTIFICATION OF CELL PLATES AND TEST PERFORMED

*POSITION IN CELL		ANALYSIS PERFORMED
NEGATIVE	POSITIVE	
1	--	None
--	2	Chemical Analysis of Active Material - Positive
3	--	Chemical Analysis of Active Material - Negative
--	4	None
5	--	None
--	6	Electrochemical Test - Positive
7	--	Electrochemical Test - Negative
--	8	Chemical Analysis of Active Material - Positive
9	--	Chemical Analysis of Active Material - Negative
--	10	Electrochemical Test - Positive
11	--	Electrochemical Test - Negative
--	12	Chemical Analysis of Active Material - Positive
13	--	Chemical Analysis of Active Material - Negative
--	14	None
15	--	None
--	16	Electrochemical Test - Positive
17	--	Electrochemical Test - Negative
--	18	None
19	--	None
--	20	None
21	--	None

*Designation of position in cell: With the negative terminal on the left, plates are numbered according to their position in the cell starting from the front.

3. Chemical Analysis of Positive and Negative Plates

Chemical analysis was performed on three negative plates and three positive plates from a discharged cell, opened in an inert atmosphere to determine the amount of active material present. The negative plate was analyzed for cadmium hydroxide ($Cd(OH)_2$), recognized as discharged active material and cadmium metal (Cd) recognized as the undischarged active material. The positive plate is analyzed by determining the amount of charged active material (NiOOH), then determining the total active material. The discharged active material ($Ni(OH)_2$) is determined by subtraction. After analyzing several positive plates it was found that the results were negligible for the charged material and the analysis to determine the charged material was discontinued. Verification that the plate was in a discharged state was determined during the electrochemical testing. Table V-2 presents a summary of the chemical analysis performed on the test plate. Each value shown in Table V-2 is an average of 12 samples obtained as follows:

Three plates per test X two slugs per plate X two samples per slug.

The chemical cell capacity was determined by multiplying the plate capacities of Table V-2 by the number of plates in the cell (11 Negative, 10 Positive). These results are presented in Table V-4.

Chemical analysis of the negative plates showed that the cell capacity, calculated from the total cadmium material present, ranged from 15 to 17 ampere-hours for cycled cells and 16 to 18 ampere-hours for uncycled cells. Thus, the cycled cells showed a loss in cadmium of approximately 1.0 ampere-hour as compared to the uncycled cells. Another observation was that the amount of charged cadmium increased with life.

Chemical analysis of cycled positive plates typically ranged in capacity from 1.0 to 1.1 ampere-hours per plate, the cell capacity was determined to be 10 to 11 ampere-hours. The uncycled plates ranged in capacity from .9 to 1.0 ampere-hours per plate, the cell capacity was 9.0 to 10.0 ampere-hours. Thus, the cycled cells appear to have increased in active material.

4. Electrochemical Analysis

After extraction and vacuum drying, three negative and three positive plates, from each cell were subjected to a flooded plate capacity test to determine the electrochemical capacity of the plate and cell.

The electrochemical capacity of each positive and negative plate was measured by subjecting the plates to charge and discharge cycles using opposing electrodes of cadmium and nickel, respectively. The following procedure was used:

1. Assemble a test cell, using the test plate and an appropriate opposing electrode. Flood the container with 31% KOH. (Wrap negative test plates in RAI gas barrier material.)

2. Discharge the test plate at a C/2 rate to 0.5 volt.

3. Baseline Test

a. Charge at a C/10 rate for 20 hours on positive test plates and 40 hours for negative test plates.

b. Discharge at a C/2 rate to 0.5 volt.

4. Steady State Test.

a. Charge at a C/3.33 rate for a 200% recharge based on the positive test plate capacity of the baseline discharge for positive test plates and a 400% recharge for negative test plates based on the Baseline discharge capacity of the positive test plate.

b. Discharge at a rate of C/2 to 0.5 volts.

c. Repeat steps a. and b. twice. Use the third steady state discharge to determine the electrochemical capacity.

Table V-2 shows the results averaged for the three plates of each cell. The capacity in each case was determined by multiplying the discharge current (C/2) by the time on discharge to reach 0.5 volts. Table V-2 also shows the utilization percentage of electrochemical-to-chemical plate capacity for negative and positive plates. Table V-4

shows the cell capacity and negative/positive ratio. The negative and positive capacities were determined by multiplying the average plate capacity by the respective number of plates. The positive plates had an electrochemical capacity of .7 to .85 ampere-hour for uncycled cells and .7 to .9 ampere-hour for cycled cells. The utilization of positive electrochemical capacity to chemical capacity was 70 to 85%. The amount of residual charged active material of the positive plate was measured to be zero in all cases. The range of data for the negative plates was .8 to 1.0 ampere-hour for cycled plates and 1 to 1.2 ampere-hours for uncycled plates -- a typical difference in capacity of .2 ampere-hours. The utilization of negative electrochemical capacity averaged about 60%. As in the chemical tests, this test revealed that the negative precharge increased with life.

5. Electrolyte Composition Analysis

The weight and composition of the electrolyte in the cell was determined by extracting the cell in a soxhlet extractor and analyzing the extract by acid titration. The following data was obtained from this test and is used in Table V-5.

The weight of electrolyte in the cell was obtained by subtracting the weight of the cell core, after extraction and vacuum drying, from the weight of the cell core before extraction. This value is reported in Table V-5 as ELECTROLYTE WW-WD.

The cell extract was analyzed to determine the amount of potassium hydroxide (KOH) and potassium carbonate (K_2CO_3) by acid titration of the OH^- and $CO_3^=$, respectively.

The weight percent concentration (CONC) of KOH in the cell was calculated by dividing the weight of KOH by the weight of electrolyte in the cell.

The volume of electrolyte in the cell was calculated by dividing the weight of electrolyte in the cell by the specific gravity of KOH.

6. Separator Patch Test

Prior to extraction, three sample patches of cell separator were removed and soaked in 50 ml of deionized water for 24 to 36 hours. The wet weight and dry weight of the sample patches was determined. The solution was analyzed by acid titration to determine the concentration of OH^- and $CO_3^=$ in the separator. This procedure worked well for new cells or cells with very few cycles but, on cells aged by cycling problems were encountered. The separator in an aged cell was usually very deteriorated, contained heavy cadmium migration, adhered to the negative plate and had to be removed from the plate by scraping with a scalpel. In many cases the separator was in such a condition that it was impossible to obtain an adequate sample for calculations to be performed. In addition, some of the analysis performed resulted in erroneous values of

KOH. These erroneous values were believed to be due to the presence of $Cd(OH)_2$ retained in the separator. During titration the $Cd(OH)_2$ interfered with neutralization of the hydroxide. Attempts to solve the problem by simply decanting or filtering the solution prior to performing the acid titration were unsuccessful. It was shown on several samples that reasonable data could be obtained by using a procedure of decanting, adding Barium-EDTA and titrating by hand.(1) However this procedure resulted in additional time and costs and the patch test was deleted.

The data presented in Table V-5 are the results obtained using standard acid titration. The amount of error due to cadmium interference that may have been induced in the separator results could not be determined, thus the results shown should be considered qualitative.

NOTE (1) This procedure was developed from NASA Technical Note TN D-8007, June 1975 and is contained in reference (3).

SUMMARY OF CHEMICAL AND PHYSICAL ANALYSIS

NOMENCLATURE FOR

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY

IDENTIFICATION

Pack No. - Identifies the test parameters of Figure IV-1 and Table IV-1.

Cell ID - Cell identification data:
- S/N - serial number
- L - Lot
- GRP - design group
- POS - position in pack

Removal Cycle - Cycle at which the cell was removed from test.

PLATE DIMENSION - Average physical dimension (weight and thickness) of plates in the cell.

CHEMICAL-CELL-CAPACITY - Calculated by multiplying the average plate analysis results of Table V-2 by 11 for negative plate and 10 for positive plate. The TOTAL NEG capacity is the summation of the charged and discharged active material.

ELECTROCHEMICAL CELL CAPACITY - Calculated by multiplying the average plate analysis results of Table V-2 by 11 for negative plates and 10 for positive plates. The values are total capacity.

NEG/POS RATIO - Electrochemical ratio of negative cell capacity to positive cell capacity.

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY

--IDENTIFICATION--				------PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					ELECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID S/N-L-CBR-POS		REPORTED CYCLE	AVE WEIGHT POS (G)	AVE WEIGHT NEG (G)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
	001 1 01		00000	6.92	8.43	.0750	.0823	17.58	.38	17.95	9.44	9.44	10.4	6.9	1.5
	013 1 02		00000	6.90	8.44	.0751	.0821	17.54	.32	17.86	9.13	9.13	9.9	6.8	1.4
	026 2 13		00000	7.20	8.73	.0791	.0849	17.63	.39	18.02	10.32	10.32	8.6	8.0	1.1
	029 1 03		00000	6.93	8.49	.0728	.0832	17.64	.32	17.96	7.99	7.99	9.9	7.2	1.4
	038 1 05		00000	6.98	8.46	.0743	.0831	17.90	.52	18.42	9.24	9.24	9.8	7.3	1.3
	051 4 10		00000	7.63	8.67	.0761	.0845				10.82	10.82	13.1	8.5	1.5
	056 1 06		00000	6.95	8.51	.0732	.0807	17.65	.39	18.03	9.52	9.52	11.7	7.0	1.7
	067 1 08		00000	6.93	8.44	.0734	.0819						11.5	6.8	1.7
	071 4 09		00000	7.44	8.75	.0755	.0847						8.8	8.4	1.0
	087 2 14		00000	7.21	8.66	.0770	.0839	17.97	.25	18.22	9.81	9.81	9.6	8.3	1.2
	130 2 15		00000	7.23	8.59	.0766	.0831	17.47	.67	18.14	10.44	10.44	13.4	8.4	1.6
	164 4 11		00000	7.56	8.68	.0739	.0856	17.90	.54	18.44	10.58	10.58	13.2	8.2	1.6
	168 4 12		00000	7.56	8.67	.0747	.0846	17.70	.68	18.38	10.76	10.76	14.1	8.2	1.7
	181 2 16		00000	7.19	8.92	.0764	.0827	18.81	.77	19.57	0.00	0.00	14.2	7.8	1.8
	213 1 04		00000	6.90	8.45	.0749	.0834	17.75	.47	18.22	8.36	8.36	11.2	7.1	1.6
	230 1 07		00000	6.87	8.54	.0736	.0839	17.56	.43	17.98	8.92	8.92	11.4	6.9	1.7
1N	138 2 09	3	10914	7.61	7.33	.0896	.0803								
2N	164 2 16	2	00948	7.63	7.79	.0970	.0823								
3N	091 4 11	1	01671	7.80	8.45	.1027	.0837								
4N	063 2 14	4	03014	7.32	7.97	.1017	.0860	12.67	2.82	15.49					
6N	056 4 09	1	00601	7.81	7.94	.0855	.0840	12.69	2.36	15.05					
7N	047 2 14	1	03136	7.64	8.20	.1012	.0816								
8N	139 4 11	2	02546	7.93	7.80	.0867	.0835	10.87	4.34	15.21					
8N	162 4 11	4	04093	7.61	8.35	.0905	.0822	14.53	2.25	16.78					
9N	019 4 12	2	15516	7.82	7.86	.0930	.0824								
10N	004 2 13	4	00033	7.34	8.48	.0901	.0867	16.05	1.36	17.41	10.30	10.30	10.9	8.8	1.2
11N	020 4 10	5	02403	8.07	7.86	.0976	.0836								
12N	088 2 15	3	02037	7.31	7.76	.0892	.0829	11.98	2.60	14.58					
13N	007 2 13	4	10818	7.32	8.03	.0953	.0825								
13N	036 2 13	2	04258	7.47	8.14	.0862	.0815								
14N	112 4 12	5	00041	7.67	8.47	.0902	.0854				11.05	11.05	12.9	8.8	1.5
15N	091 2 15	4	02707	7.40	7.45	.0972	.0819	12.97	2.90	15.87					

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION--					-----PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					ELECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID S/N-L-G-R-POS			REMOVAL CYCLE	AVE WEIGHT POS (G)	AVE WEIGHT NEG (G)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
16N	027	4	10	4	06253	7.86	7.37	.0884	.0819							
16N	028	4	10	5	05653	7.88	7.52	.0904	.0812	10.64	3.53	14.17				
17N	144	4	11	4	01265	7.71	7.98	.0920	.0839	14.38	1.68	16.06				
18N	069	2	14	4	05221	7.55	7.66	.0860	.0816							
18N	070	2	14	3	10483	7.58	7.54	.0935	.0827							
19N	077	4	09	4	02344	7.65	8.31	.0853	.0829	14.66	1.84	16.50				
20N	147	2	16	3	14366	7.37	7.66	.0903	.0804							
20N	167	2	16	1	06178	7.56	8.10	.0856	.0800							
21N	073	2	14	5	00420	7.44	8.05	.0943	.0842							
22N	098	4	11	2	02722	7.74	8.00	.0853	.0854							
23N	152	2	16	5	04585	7.42	7.94	.1005	.0819	11.81	4.35	16.16				
24N	079	4	09	3	01944	7.99	8.18	.1175	.0832							
26N	095	2	15	4	11064	6.97	7.90	.0900	.0821							
27N	113	4	12	3	02537	7.75	7.95	.0822	.0822	13.81	1.70	15.51				
28N	027	2	13	1	02033	7.71	8.32	.0971	.0850	16.34	.49	16.83				
29N	098	2	15	4	00034	7.13	8.52	.0813	.0845				10.88	10.88	8.0	9.2	.9
30N	009	4	10	2	03570	7.51	7.52	.1086	.0865							
30N	033	4	10	4	05621	7.83	8.13	.0840	.0819	15.41	1.64	17.05				
30N	034	4	10	5	07459	7.77	8.09	.0814	.0810							
31N	010	2	13	4	04449	7.43	7.77	.0957	.0821	12.48	2.02	14.50				
32N	117	4	12	4	02933	8.01	7.84	.1060	.0844							
34N	150	4	11	4	02966	7.43	8.42	.0957	.0832	12.96	4.33	17.30				
35N	154	2	16	4	04045	7.36	7.73	.0793	.0836	12.88	2.02	14.90				
35N	172	2	16	1	00429	7.34	8.35	.0808	.0954	14.39	3.26	17.66	10.73	10.73	10.7	7.9	1.3
36N	082	4	09	5	01328	7.63	8.30	.1008	.0865	14.04	2.52	16.56				
37N	152	4	11	3	01215	7.70	8.87	.0817	.0815							

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION--					-----PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					ELECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID S/N-L-SEQ-POS			REMOVAL CYCLE	AVE WEIGHT POS (G)	AVE WEIGHT NEG (G)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
38N	077 2 14		3	06172	6.91	8.14	.0901	.0812	15.05	1.96	17.01					
39N	085 4 09		3	09660	7.64	7.89	.0865	.0829								
39N	086 4 09		4	05227	7.72	8.01	.0793	.0822	12.99	2.59	15.58					
40N	156 2 16		3	00590	7.73	7.94	.1020	.0799	10.93	4.07	15.00					
41N	102 2 15		4	00405	6.97	8.31	.0823	.0826	15.23	2.27	17.50					
42N	036 4 10		4	00958	7.87	7.91	.0886	.0833								
43N	031 2 13		1	10333	7.49	8.06	.0886	.0796								
44N	120 4 12		4	02540	7.95	7.91	.1324	.0843								
45N	040 4 10		5	01537	7.90	8.02	.0835	.0823	15.14	.80	15.95					
46N	104 2 15		3	02973	7.07	7.86	.0992	.0829	11.41	4.38	15.79					
47N	123 4 12		4	07776	7.73	8.23	.0823	.0804								
48N	015 2 13		3	00756	7.56	8.23	.1030	.0835	15.20	1.46	16.66					
49N	177 2 16		2	01657	7.54	8.01	.0840	.0809								
50N	069 4 09		2	01578	7.89	8.37	.0882	.0820	15.47	1.97	17.44					
52N	156 4 11		4	09960	7.58	8.08	.0806	.0818								
53N	137 2 09		5	06813	7.44	8.35	.0943	.0833								
54N	168 2 16		4	01941	7.48	8.39	.0827	.0807	15.81	1.75	17.56					
56N	085 2 14		5	03760	7.09	7.87	.0803	.0826	14.18	.77	14.95					
57N	019 2 13		3	02451	7.39	8.06	.0843	.0823	9.67	3.84	13.50					
58N	099 4 12		1	01534	7.60	8.06	.0885	.0830	12.31	3.83	16.14					
59N	108 2 15		4	01613	7.48	8.35	.1085	.0832								
60N	042 4 10		3	08615	7.74	8.12	.0775	.0808								
61N	129 4 12		4	02115	7.72	8.10	.0772	.0827	14.41	1.21	15.63					
62N	022 2 13		3	02556	7.50	7.85	.0939	.0833	14.50	1.21	15.71					

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION--				-----PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					ELECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID		SEQUENCE	AVE WIDTH POS (CM)	AVE WEIGHT NEG (GM)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
63N	047 4 10	4	00945	7.97	8.09	.1175	.0850	12.48	4.69	17.17					
65N	108 1 04	1	01167	7.27	7.77	.0970	.0814	13.77	2.63	16.40	9.92	9.92	10.7	7.3	1.5
65N	109 1 04	2	05661	7.23	7.74	.0946	.0838	14.47	1.37	16.84	9.85	9.85	10.0	7.5	1.3
65N	110 1 04	3	04157	7.23	7.73	.0917	.0852	13.59	2.41	15.99			11.3	7.6	1.5
65N	133 1 04	4	04176	7.21	7.81	.0919	.0841	14.83	1.52	16.34			10.6	7.9	1.3
65N	134 1 04	5	04562	7.15	7.77	.0937	.0839	14.57	1.29	15.84			10.7	7.8	1.4
65N	135 1 04	6	02053	7.16	8.10	.0867	.0845	16.39	.98	17.38	9.71	9.71	10.5	7.7	1.4
65N	136 1 04	7	01504	7.15	7.99	.0813	.0843	15.37	.94	16.31	9.62	9.62	10.4	7.0	1.5
65N	137 1 04	8	00771	7.03	7.97	.0787	.0839	14.94	2.06	16.99	8.90	8.90	9.5	7.3	1.3
66N	142 1 04	8	00313	7.91	8.16	.0779	.0805	16.24	1.13	17.37	10.17	10.17	8.1	8.1	1.0
67N	114 1 04	1	04262	7.22	7.57	.0794	.0841	11.48	4.44	15.94	9.83	9.83	9.5	6.5	1.5
67N	151 1 04	4	14066	7.21	7.42	.0842	.0830	12.48	2.21	14.68	9.41	9.41	10.6	6.6	1.6
67N	152 1 04	5	13663	7.24	7.41	.0838	.0831	12.61	2.37	14.98	9.85	9.85			
67N	153 1 04	6	06876	7.11	7.91	.0784	.0884	15.16	1.44	16.60	10.00	10.00	10.1	7.0	1.4
67N	154 1 04	7	04500	7.08	7.97	.0806	.0892	13.60	3.39	16.99	11.74	11.74	12.9	7.8	1.6
67N	155 1 04	8	03253	7.04	8.02	.0774	.0851	14.99	1.69	16.68	7.38	7.38	11.2	7.1	1.6
68N	117 1 04	1	00524	7.22	7.92	.0897	.0840	12.56	3.68	16.25	10.36	10.36	11.3	7.9	1.4
68N	118 1 04	2	00472	7.33	7.91	.0879	.0887	11.77	4.65	16.22	10.80	10.80	8.0	8.6	.9
68N	119 1 04	3	00524	7.30	7.86	.0898	.0855	14.18	2.93	17.11	10.34	10.34	7.2	9.0	.8
68N	156 1 04	4	00955	7.26	7.25	.1006	.0853	12.95	4.31	16.56	10.23	10.23	4.4	9.0	.5
68N	157 1 04	5	00955	7.34	7.86	.0954	.0872	13.00	2.98	15.98	11.17	11.17	10.4	8.6	1.2
68N	158 1 04	6	00300	7.21	7.82	.0863	.0879	11.29	4.34	15.56	10.47	10.47	10.5	8.2	1.3
68N	159 1 04	7	00200	7.19	7.98	.0825	.0829	13.70	1.67	15.36	10.74	10.74	11.6	7.9	1.5
68N	160 1 04	8	00100	7.13	8.08	.0797	.0829	13.64	3.27	16.90	9.74	9.74	10.8	7.7	1.4
69N	120 1 04	1	00592	7.18	7.96	.0825	.0847	13.30	3.18	16.49	10.32	10.32	11.4	9.0	1.3
69N	121 1 04	2	00533	7.17	8.14	.0825	.0826	15.02	1.86	16.89	9.77	9.77	10.9	8.5	1.3
69N	122 1 04	3	00172	7.10	8.23	.0787	.0829	16.59	1.20	17.79	9.64	9.64	11.8	6.9	1.7
69N	161 1 04	4	00162	6.98	8.13	.0766	.0828	11.98	1.98	13.96	9.30	9.30	11.3	7.4	1.5
69N	162 1 04	5	00148	6.96	8.11	.0762	.0815	14.77	2.28	17.05	9.34	9.34	10.1	7.6	1.3
69N	163 1 04	6	00149	6.95	8.16	.0758	.0820	14.92	1.98	16.92	9.22	9.22	8.5	7.5	1.1
69N	164 1 04	7	00172	7.0[illegible]	7.97	.0775	.0819	15.39	1.82	17.21	10.52	10.52	12.1	7.7	1.6
70N	123 1 04	1	00634	7.22	7.71	.0875	.0853	10.08	5.44	15.52	11.89	11.89	7.2	8.6	.8
70N	126 1 04	2	01512	7.24	7.60	.0923	.0857	9.84	5.72	15.57	10.62	10.62	6.4	8.2	.8
70N	127 1 04	3	00648	7.30	7.80	.0850	.0842	12.11	4.96	17.07			9.7	7.7	1.2
70N	166 1 04	4	01512	7.24	7.81	.0920	.0945	12.10	3.16	15.26	10.23	10.23	3.7	8.3	.4
70N	167 1 04	5	01512	7.13	7.73	.0930	.0948	11.81	2.86	14.67	9.84	9.84	8.5	7.7	1.1
70N	168 1 04	6	01201	7.17	7.49	.0868	.0926	12.07	4.19	16.26	8.61	8.61	9.7	7.9	1.2

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION--					------PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					FLECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID S/N-L-SBR-DS			DEMOVA CODE	AVE WEIGHT DRY (GM)	AVE WEIGHT WF (GM)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CO(OH)2 (AH)	CO (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
70N	169	1	04	7	00856	7.00	7.00	.0814	.0924	13.13	4.39	17.52	9.57	9.57	10.2	7.4	1.4
70N	170	1	04	8	00401	7.08	8.09	.0831	.1013	14.71	2.90	17.61	9.30	9.30	9.0	7.6	1.2
71N	128	1	04	1	01531	7.25	7.39	.0894	.0865	7.27	6.36	13.63	10.61	10.61	10.0	7.3	1.4
71N	129	1	04	2	01538	7.20	7.23	.0925	.0853	6.63	6.45	13.08	10.32	10.32	9.1	7.9	1.1
71N	130	1	04	3	01192	7.24	7.47	.0841	.0814	9.00	5.96	14.96	10.64	10.64	10.3	7.6	1.3
71N	171	1	04	4	01422	7.30	7.51	.0905	.0939	11.04	4.15	15.19	10.56	10.56	9.6	8.3	1.2
71N	172	1	04	5	01415	7.34	7.45	.0892	.0878	8.32	6.10	14.42	10.51	10.51	9.1	8.2	1.1
71N	173	1	04	6	01357	7.24	7.58	.0893	.0915	9.28	5.65	14.92	10.25	10.25	8.7	7.8	1.1
71N	176	1	04	7	01540	7.37	7.49	.0935	.0860	11.49	3.17	14.67	10.83	10.83	9.1	8.1	1.1
71N	177	1	04	8	00762	7.15	7.93	.0845	.0897	13.69	3.10	16.79	9.85	9.85	9.2	7.7	1.2
72N	131	1	04	1	01351	7.16	7.83	.0913	.0889	10.41	3.48	13.89	10.12	10.12	9.2	8.1	1.1
72N	132	1	04	2	01717	7.29	7.90	.0987	.0857	10.67	6.01	16.68	10.59	10.59	8.4	8.6	1.0
72N	178	1	04	4	01717	7.22	7.83	.1096	.0834	9.63	5.38	15.01	10.81	10.81	6.8	8.4	.8
72N	179	1	04	3	01352	7.2[illegible]	7.81	.0890	.0845	11.73	4.41	16.15	10.02	10.02	7.6	7.8	1.0
72N	191	1	04	5	01717	7.30	7.87	.1050	.0830	11.56	4.39	15.95	10.88	10.88	7.0	8.3	.8
72N	192	1	04	6	00149	6.94	8.10	.0781	.0853	16.18	1.56	17.74	9.15	9.15	6.3	8.0	.8
72N	193	1	04	7	00101	7.03	9.20	.0790	.0831	16.40	.50	16.90	9.03	9.03	9.5	7.4	1.3
72N	194	1	04	8	00059	6.90	8.18	.0773	.0839	15.75	.99	16.73	9.24	9.24	10.3	8.6	1.2
73N	180	1	04	1	02233	7.21	7.68	.0896	.0828	10.85	5.44	16.28	9.95	9.95	10.1	7.6	1.3
73N	181	1	04	2	03501	7.39	7.52	.0991	.0834	8.28	6.74	15.02	10.58	10.58	8.9	7.8	1.1
73N	182	1	04	3	03501	7.45	7.52	.0984	.0863	9.61	6.90	15.51	14.17	14.17	9.4	8.3	1.1
73N	195	1	04	4	03501	7.46	7.59	.0993	.0851	9.96	5.29	15.25	11.72	11.72	10.1	8.7	1.2
73N	196	1	04	5	03501	7.43	7.51	.0983	.0869	10.60	4.71	15.11	10.83	10.83	8.9	8.3	1.1
73N	197	1	04	6	00867	7.16	7.88	.0857	.0885	12.02	4.12	16.14	10.67	10.67	10.3	7.7	1.3
73N	198	1	04	7	00624	7.17	8.06	.0827	.0836	15.52	1.73	17.25	10.49	10.49	9.4	7.7	1.2
73N	202	1	04	8	00473	7.06	7.86	.0832	.0873	11.39	5.50	16.89	10.24	10.24	10.2	7.7	1.3
74N	183	1	04	1	01194	7.15	7.75	.0869	.0821	13.73	4.05	17.78	10.39	10.39	9.5	6.2	1.5
74N	185	1	04	2	01196	7.11	7.67	.0877	.0817	5.28	5.39	10.67	9.25	9.25	8.9	7.6	1.2
74N	187	1	04	3	01751	7.28	7.55	.0930	.0852	9.88	6.46	16.34	10.73	10.73	10.5	7.4	1.4
74N	203	1	04	4	01408	7.21	7.71	.0973	.0871	10.96	4.37	15.33	9.55	9.55	4.6	8.0	.6
74N	204	1	04	5	01811	7.19	7.69	.0954	.0854	11.64	4.22	15.86	10.14	10.14	5.3	8.1	.6
74N	205	1	04	6	00375	7.12	8.11	.0826	.0861	15.49	1.46	16.95	9.94	9.94	9.1	7.6	1.2
74N	206	1	04	7	00250	7.07	8.04	.0819	.0853	14.79	2.24	17.03	9.80	9.80	11.9	8.1	1.5
74N	207	1	04	8	00141	7.11	8.04	.0785	.0867	14.11	3.93	18.04	8.72	8.72	8.3	7.8	1.1
75N	002	1	01	4	02560	7.31	7.72	.0957	.0842	12.58	3.90	16.48	10.09	10.09	10.6	8.9	1.2
75N	003	1	01	5	02486	7.25	7.66	.0987	.0863	9.78	5.79	15.57	9.89	9.89	12.1	8.6	1.4
75N	004	1	01	6	02250	7.19	7.78	.0903	.0854	12.74	4.45	17.19	10.83	10.83	9.2	8.2	1.1
75N	005	1	01	7	01505	7.13	7.91	.0833	.0820	12.73	3.99	16.72	10.00	10.00	9.9	7.9	1.3
75N	006	1	01	8	00750	7.27	7.98	.0804	.0893				9.55	9.55	12.3	7.7	1.6
75N	010	1	01	1	02505	7.32	7.69	.0974	.0856	9.75	6.04	15.79	11.48	11.48	7.9	8.7	.9
75N	011	1	01	2	01835	7.22	7.73	.0889	.0832	9.56	7.13	16.49	10.64	10.64	8.3	8.3	1.0

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION-- PACK NO.	CELL ID SYN-L-CELL-POS	REMOVAL CYCLE	-----PLATE DIMENSIONS------ AVE WEIGHT POS (G)	NEG (G)	AVE THICKNESS POS (CM)	NEG (CM)	----------CHEMICAL-CELL-CAPACITY---------- CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	ELECTROCHEMICAL CELL CAPACITY NEG (AH)	POS (AH)	NEG/POS RATIO
75N	012 1 01 3	01535	7.25	7.82	.0889	.0819	11.69	5.10	16.79	10.54	10.54	10.1	8.3	1.2
76N	228 1 07 1	01322	7.31	7.65	.0914	.0811	10.79	4.68	15.46	9.81	9.81	10.3	8.0	1.3
76N	229 1 07 2	01669	7.44	7.61	.0991	.0826	10.23	5.73	15.96	11.25	11.25	9.0	8.4	1.1
76N	231 1 07 3	01115	7.45	7.64	.1004	.0843	11.41	4.72	16.13	10.76	10.76	10.0	8.8	1.1
76N	232 1 07 4	01669	7.35	7.54	.0928	.0833	9.64	5.84	15.48	10.01	10.01	7.5		
76N	233 1 07 5	01663	7.45	7.66	.0995	.0860	12.01	4.21	16.22	13.28	13.28	9.7	8.2	1.2
76N	234 1 07 6	00874	7.26	7.62	.0925	.0846	10.79	4.99	15.78	12.37	12.37	8.9	8.3	1.1
76N	235 1 07 7	00623	7.43	7.75	.0913	.0873	14.56	2.48	17.04	12.66	12.66	10.4	8.7	1.2
76N	236 1 07 8	00428	7.23	7.96	.0867	.0832	15.75	1.16	16.91	11.54	11.54	11.0	8.3	1.3
77N	014 1 02 4	01909	7.18	7.97	.0999	.0840	14.93	1.54	16.47	10.74	10.74	10.5	8.5	1.2
77N	015 1 02 5	01909	7.12	8.01	.1029	.0863	12.90	.95	13.85	7.45	7.45	10.6	8.0	1.3
77N	016 1 02 6	01504	7.14	7.83	.0904	.0872	13.88	2.09	15.96	10.20	10.20	11.1	9.5	1.2
77N	017 1 02 7	01111	7.18	7.86	.0871	.0862	13.95	2.67	16.61	10.36	10.36	12.0	9.2	1.3
77N	018 1 02 8	00615	7.15	7.93	.0849	.0849	12.81	3.94	16.75	10.38	10.38	10.8	8.9	1.2
77N	021 1 02 3	01909	7.19	7.93	.1106	.0882	13.53	3.02	16.54	9.75	9.75	11.1	7.9	1.4
77N	022 1 02 2	01909	7.21	7.92	.0974	.0846	14.90	1.88	16.78	10.12	10.12	11.5	8.8	1.3
77N	026 1 02 1	01909	7.11	7.94	.1078	.0891	14.92	2.11	17.03	10.72	10.72	8.5	7.3	1.2
78N	053 1 06 4	02354	7.20	7.63	.0964	.0856	12.15	3.89	16.04	10.09	10.09	7.8	7.1	1.1
78N	054 1 06 5	02369	7.25	7.63	.0960	.0858	11.22	4.44	15.46	11.21	11.21	10.1	8.2	1.2
78N	055 1 06 6	00748	7.16	8.00	.0812	.0824	14.81	2.55	17.36	9.73	9.73	9.7	7.5	1.3
78N	057 1 06 7	00509	7.26	8.02	.0793	.0871	15.51	2.30	17.81	9.41	9.41	8.2	7.5	1.1
78N	058 1 06 8	00251	7.02	8.09	.0779	.0863	15.27	2.84	18.11	9.07	9.07	10.6	7.3	1.5
78N	064 1 06 1	02367	7.29	7.69	.0936	.0836	8.21	5.95	16.16	9.74	9.74	11.4	5.9	1.9
78N	065 1 06 2	02365	7.29	7.67	.0941	.0837	13.16	3.85	16.91	10.56	10.56	8.7	7.6	1.1
78N	066 1 06 3	02354	7.24	7.68	.0929	.0838	12.54	3.42	15.96	10.81	10.81	10.8	7.5	1.4
79N	027 1 03 4	03679	7.27	7.84	.1027	.0864	14.44	2.36	17.80			9.1	7.8	1.2
79N	028 1 03 5	03712	7.22	8.03	.1001	.0875	14.75	1.69	16.44	10.86	10.86	8.1	8.1	1.0
79N	030 1 03 6	01463	7.20	7.94	.0873	.0844	13.86	3.01	16.87	9.50	9.50	9.0	8.7	1.0
79N	031 1 03 7	01112	7.07	7.92	.0861	.0849	12.17	3.69	15.86	10.23	10.23	10.9	7.9	1.4
79N	032 1 03 8	00580	7.06	8.18	.0843	.0859	14.48	.89	17.37	10.26	10.26	8.7	8.1	1.1
79N	035 1 03 3	01480	7.26	7.87	.0943	.0826	13.31	3.22	16.52	10.75	10.75	10.0	8.2	1.2
79N	036 1 03 2	03311	7.32	7.92	.0885	.0849	12.66	3.96	16.43	10.67	10.67	10.9	8.4	1.3
79N	037 1 03 1	03364	7.32	7.74	.0907	.0809	10.65	5.80	16.25	10.95	10.95	7.3	8.1	.9
80N	039 1 05 4	02320	7.12	7.74	.0943	.0861	11.65	4.30	15.95	10.04	10.04	7.5	8.0	.9
80N	040 1 05 5	02448	7.17	7.85	.0916	.0831	12.52	3.31	15.83	9.43	9.43	9.4	8.3	1.1
80N	041 1 05 6	01425	7.08	7.97	.0899	.0888	14.70	1.79	14.49	9.71	9.71	11.1	8.6	1.3
80N	042 1 05 7	00953	7.09	7.95	.0830	.0905	14.47	2.78	17.25	9.69	9.69	10.1	7.8	1.3
80N	043 1 05 8	00511	7.10	8.08	.0803	.0836	15.32	1.45	16.77	10.26	10.26	11.0	7.4	1.5
80N	049 1 05 1	03360	7.37	7.61	.0989	.0837	12.17	4.69	16.85	9.68	9.68	8.9	7.5	1.2
80N	051 1 05 2	02320	7.15	7.64	.1046	.0853	13.58	6.07	19.45	9.61	9.61	8.7		
80N	052 1 05 3	02320	7.38	7.77	.0968	.0876	12.81	3.57	16.38	9.96	9.96	9.1	8.1	1.1

TABLE V-4 PLATE DIMENSIONS AND CELL CAPACITY (continued)

--IDENTIFICATION--				-----PLATE DIMENSIONS------				----------CHEMICAL-CELL-CAPACITY----------					ELECTROCHEMICAL CELL CAPACITY		NEG/POS RATIO
PACK NO.	CELL ID S/N-I-GRP-POS		REMOVAL CYCLE	AVE WEIGHT POS (GM)	AVE WEIGHT NEG (GM)	AVE THICKNESS POS (CM)	AVE THICKNESS NEG (CM)	CD(OH)2 (AH)	CD (AH)	TOTAL NEG (AH)	NI(OH)2 (AH)	TOTAL POS (AH)	NEG (AH)	POS (AH)	
R1N	189 1 04	1	03014	7.27	7.69	.0966	.0850	12.51	4.00	16.51	0.00	0.00	8.7	6.3	1.4
R1N	190 1 04	2	01580	7.17	7.93	.0944	.0888	14.93	1.98	16.91	10.00	10.00	8.2	7.2	1.1
R1N	208 1 04	4	03055	7.34	7.62	.0942	.0854	10.98	5.65	16.63	0.00	0.00	9.4	5.8	1.6
R1N	209 1 04	5	03055	7.33	7.69	.0954	.0863	11.75	5.02	16.77	0.00	0.00	8.2	6.4	1.3
R1N	210 1 04	6	01510	7.45	7.84	.0885	.0850	13.01	3.60	16.60	9.87	9.87	10.0	7.5	1.3
R1N	211 1 04	7	01001	7.[illegible]	8.02	.0856	.0856	14.21	2.39	16.60	9.82	9.82	11.4	7.5	1.5
R1N	212 1 04	8	00502	7.04	8.00	.0806	.0865	15.34	1.86	17.18	9.37	9.37	10.6	6.8	1.6
R1N	224 1 04	3	01040	7.25	7.79	.0806	.0813	11.41	5.89	17.30	9.90	9.90	8.4	6.5	1.3
R2N	291 1 04	1	00678	7.03	8.17	.0834	.0864	16.58	.24	16.82	10.12	10.12	12.0	7.3	1.7
R2N	292 1 04	2	00678	7.02	8.16	.0831	.0860	16.63	.29	16.92	9.81	9.81	12.2	8.8	1.4
R2N	295 1 04	5	00678	7.05	8.18	.0852	.0854	17.03	.32	17.35	9.79	9.79	10.9	8.4	1.3
R3N	071 1 08	6	00000	7.08	7.84	.0810	.0856	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
R3N	073 1 08	8	00000	7.13	7.91	.0772	.0823	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
R3N	099 1 08	2	00000	7.13	7.93	.0787	.0844	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
R4N	084 1 08	7	00000	7.01	7.48	.0763	.0828	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
R6N	089 1 08	6	00000	7.24	7.59	.0827	.0819	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
R7N	219 1 04	1	00000	7.38	7.87	.0747	.0822	14.13	.33	14.46	9.35	9.35	10.7	7.3	1.5
R7N	220 1 04	2	00000	7.22	8.21	.0766	.0806	17.01	.20	17.22	8.98	8.98	8.9	8.1	1.1
R7N	221 1 04	3	00000	6.88	8.31	.0739	.0819				9.28	9.28	12.6	7.3	1.7
R9N	216 1 01	1	00000	6.86	8.44	.0751	.0852	17.85	.56	18.41	9.13	9.13	11.5	6.6	1.7
R9N	217 1 01	2	00000	6.87	8.48	.0754	.0850	17.95	.41	18.37			11.1	6.8	1.6
R9N	218 1 01	3	00000	6.92	8.44	.0756	.0854	16.83	.31	17.14			12.0	7.0	1.7
R9N	237 1 01	1	00000	7.02	8.20	.0771	.0821	17.02	.52	17.54	9.37	9.37	12.6	7.6	1.7
R9N	238 1 01	2	00000	6.92	8.21	.0771	.0848	16.94	.43	17.37	9.51	9.51	11.9	7.7	1.5
R9N	239 1 01	3	00000	6.87	8.25	.0760	.0831	16.56	.69	17.26	10.55	10.55	12.1	7.8	1.6
R1N	059 1 06	1	00000	6.84	8.36	.0738	.0835	17.02	.41	17.43	8.90	8.90	12.3	6.4	1.9
R1N	060 1 06	2	00000	6.83	8.31	.0768	.0845	17.14	.77	17.91			11.3	6.4	1.8
R1N	061 1 06	3	00000	6.84	8.41	.0750	.0848	17.73	.78	18.51			11.9	7.2	1.7
R2N	044 1 05	1	00000	6.92	8.36	.0728	.0820	17.91	.60	18.50	9.92	9.92	12.3	7.0	1.8
R2N	045 1 05	2	00000	6.84	8.31	.0746	.0817	16.30	.88	17.18	9.50	9.50	12.1	7.3	1.7
R2N	046 1 05	3	00000	6.92	8.30	.0737	.0831	17.46	.36	17.82	9.27	9.27	12.0	7.5	1.6

SUMMARY OF CHEMICAL AND PHYSICAL ANALYSIS

NOMENCLATURE FOR

TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS

IDENTIFICATION

Pack No. - Identifies the test parameters of Figure IV-1 and Table IV-1.

Cell ID - Cell identification data:
S/N - serial number
L - Lot
GRP - design group
POS - position in pack

Removal Cycle - Cycle at which the cell was removed from test.

ELECTROLYTE WW-WD - Wet weight of cell core before extraction minus the dry weight of cell case after extraction.

CELL EXTRACT ANALYSIS

KOH - Potassium hydroxide, determined by acid titration to neutralize OH^-.

$K_2CO_3^=$ - Potassium carbonate, determined by acid titration to neutralize $CO_3^=$.

CELL KOH:

CONC - Concentration by weight percent of potassium hydroxide in the cell KOH(G) divided by (WW-WD).

AMOUNT - Volume (cubic centimeters) of electrolyte in the cell. (WW-WD) divided by specific gravity of KOH.

SEPARATOR PATCH TEST:

KOH - Amount of potassium hydroxide (in grams) in separator as determined by acid titration to neutralize OH^-.

K_2CO_3 - Amount of potassium carbonate (in grams) in separator as determined by acid titration to neutralize $CO_3^=$.

ELECTROLYTE RENTENTIONS

(G)E/(G)SEP - Weight (grams) of electrolyte in the separator divided by the weight (grams) of separator.

(G)/(CC) - Weight (grams) of electrolyte in the separator divided by the volume of the separator patch.

TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS

PACK NO.	IDENTIFICATION S/N-L-GRP-POS		REMOVAL CYCLE	ELECTROLYTE +W-W (G)	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL CONC	KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	PATCH-TEST ELECTROLYTE-RETENTIONS (G)E/(G)SEP	PATCH-TEST ELECTROLYTE-RETENTIONS (G) / (CC)
	101 1 01		00000		2.[illegible]	3.93						
	013 1 02		00000		4.99	2.78			.0452	.0540	1.69	.28
	026 2 13		00000	22.20	10.12	3.21	45.58	16.88	.0804	.0506	1.97	.30
	029 1 03		00000		4.56	2.45			.1012	.0321	1.65	.20
	038 1 05		00000		5.74	2.83			.0594	.0350	1.33	.21
	051 4 10		00000	21.50	5.22	1.67	24.37	17.58	.1052	.0573	2.29	.45
	056 1 06		00000		5.12	2.59			.1045	.0331	2.39	.37
	067 1 08		00000		5.06	2.79			.0811	.0455	1.98	.32
	071 4 09		00000	21.00	4.43	1.72	21.05	17.14	.0833	.0442	1.68	.27
	087 2 14		00000	25.90	7.00	2.90	27.01	19.81	.0595	.0441	2.24	.30
	130 2 15		00000	23.00	6.37	2.92	27.70	17.53	.1227	.0711	2.67	.34
	164 4 11		00000	20.80	4.22	2.30	20.28	17.00	.0888	.0590	1.64	.22
	168 4 12		00000	23.60	4.75	2.66	20.13	19.26	.0811	.0534	2.03	.28
	181 2 16		00000	25.60	.98	3.48	3.83	19.59	.0898	.0539	2.31	.34
	213 1 04		00000		5.22	2.41			.1221	.0708	2.34	.03
	230 1 07		00000		8.02	2.23			.0888	.0449	2.17	.32
1N	138 2 09	3	10914	34.10	4.88	5.57	14.32		.1189	.0396	2.11	.31
2N	164 2 16	2	00948	30.30	.19	.83	.61					
3N	091 4 11	1	01671	23.50	.33	.32	1.41					
4N	063 2 14	4	03014	33.70	3.26	7.70	9.69					
6N	056 4 09	1	00601	24.80	2.35	4.65	9.49					
7N	047 2 14	1	03136	28.50	.59	.42	2.05					
8N	139 4 11	2	02566	25.30	1.65	5.16	6.51					
8N	162 4 11	4	04099	25.60	2.09	4.62	8.17	20.78				
9N	019 4 12	2	15516									
10N	004 2 13	4	00032	24.30	5.46	1.93	26.56	18.46	.0662	.0321	1.71	.21
11N	020 4 10	5	02402	27.60	.37	.38	1.32					
12N	088 2 15	3	02037	27.40	3.14	6.24	11.53					
13N	007 2 13	4	10818	30.20	4.07	5.04	13.47					
13N	036 2 13	2	04258	26.40	4.59	4.32	17.38					
14N	1.[illegible] 4 12	5	00041	25.40	4.47	2.33	17.60	20.74	.0769	.0552	2.85	.44
15N	091 2 15	4	02707		4.84	4.05						

TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK NO.	IDENTIFICATION S/N-L-GRP-POS	REMOVAL CYCLE	ELECTROLYTE	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	CELL KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	PATCH-TEST ELECTROLYTE-RETENTIONS (G)F/(G)SEP	PATCH-TEST ELECTROLYTE-RETENTIONS (G) / (CC)
16N	027 4 10 4	06253 [illegible]		2.07	5.44	6.36	0.00				
16N	028 4 10 5	05653 28.80		2.20	5.42	7.62	23.34				
17N	144 4 11 4	01265 24.00		1.03	2.25	4.30	0.00			1.35	
18N	069 2 14 4	05221 30.20		5.24	4.47	17.35	0.00				
18N	070 2 14 3	10433 27.30		4.29	4.54	15.70	0.00				
19N	077 4 09 4	02344 25.10		2.26	4.30	9.00	20.37				
20N	147 2 16 3	14366 32.30		5.84	4.25	18.09	0.00			3.55	
20N	167 2 16 1	06178 30.40		5.77	4.07	18.99	0.00				
21N	073 2 14 5	00420 29.60		.58	.44	1.96	0.00				
22N	098 4 11 2	02722 25.30		2.33	4.01	9.20	0.00				
23N	152 2 16 5	04585 32.70		3.44	7.23	10.54	0.00				
24N	079 4 09 3	01944 26.10		.23	.45	.87	0.00				
26N	095 2 15 4	11064 28.20		4.43	4.18	15.70	21.34	.0282	.0405	1.09	.01
27N	113 4 12 3	02537 24.90		2.13	5.16	8.56	20.21			1.65	
28N	027 2 13 1	02033 22.00		5.22	3.69	23.73	0.00				
29N	098 2 15 4	00034 24.80		5.22	3.68	21.05	18.86	.0537	.0601	1.88	.29
30N	009 4 10 2	03570 29.20		1.36	5.75	4.65	0.00				
30N	033 4 10 4	05621 26.40		1.24	2.26	4.71	21.52			2.80	.01
30N	034 4 10 5	07459 26.40		3.23	3.55	12.22	21.50	.0450	.0663	2.27	.01
31N	010 2 13 4	04449 28.20		4.84	4.28	17.16	0.00				
32N	117 4 12 4	02933 27.60		3.72	3.32	13.48	0.00				
34N	150 4 11 4	02966 0.00		1.90	4.53	0.00	0.00			4.12	
35N	154 2 16 4	04045 0.00		6.19	3.73	0.00	0.00			.50	
35N	172 2 16 1	00429 24.30		6.44	3.37	22.76	21.46	.0521	.0547	1.75	.26
36N	082 4 09 5	01328 24.20		3.27	3.45	13.53	19.48	.0107	.0221	.60	.04
37N	152 4 11 3	01215 21.30		3.45	3.00	16.21	0.00				

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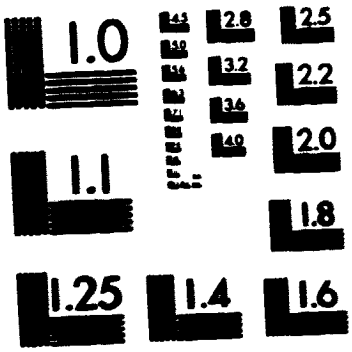
TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK NO.	IDENTIFICATION S/N-L-SUP-POS		REMOVAL (CC)	ELECTROLYTE (CC)	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	CELL KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	PATCH-TEST ELECTROLYTE-RETENTIONS (G)E/(G)SEP	PATCH-TEST ELECTROLYTE-RETENTIONS (G) / (CC)
38N	077 2 14	3	01172	30.30	3.23	7.24	10.45	0.00				
39N	085 4 09	3	00940	23.40	1.76	5.67	7.53	18.94				
39N	086 4 09	4	05322	0.00	3.26	3.20	0.00	0.00	.0109	.0343	1.13	.01
											1.12	
40N	156 2 16	3	00530	31.70	3.56	7.41	11.22	0.00				
41N	102 2 15	4	02405	22.50	5.05	3.87	22.45	0.00				
42N	036 4 10	4	00950	30.60	.19	.60	.64	0.00				
43N	031 2 13	1	10222	28.00	5.66	3.18	20.21	0.00				
44N	120 4 12	4	02540	29.40	.26	.50	.89	0.00				
45N	040 4 10	5	01537	25.30	4.32	2.83	17.09	20.59				
46N	106 2 15	3	02973	28.50	2.57	7.17	9.00	0.00			1.55	.01
47N	123 4 12	4	07776	27.80	.34	.34	1.23	0.00				
48N	015 2 13	3	00756	25.10	4.65	4.48	18.53	18.93				
49N	177 2 16	3	01657	32.50	.39	.65	1.21	0.00			1.52	
50N	069 4 09	3	01578	22.10	1.55	1.54	7.01	17.93				
52N	156 4 11	4	09960	26.10	3.22	3.21	12.35	0.00			1.51	.01
53N	137 2 09	5	04813	22.90	2.05	4.93	8.97	18.47				
54N	168 2 16	4	01941	20.90	1.41	1.77	6.75	15.85			1.12	
56N	085 2 14	5	03760	28.00	2.43	2.27	8.68	21.42			1.29	.01
57N	019 2 13	3	02451	30.50	2.79	7.12	9.15	0.00			1.79	.02
58N	049 4 12	1	01534	26.40	4.23	2.88	16.04	21.40				
59N	108 2 15	4	01613	26.70	.43	.40	1.62	0.00			1.51	.12
60N	042 4 10	3	04615	28.50	.40	.34	1.40	0.00				
61N	129 4 12	4	02115	24.80	1.85	5.14	7.44	0.00				
62N	022 2 13	3	02556	25.20	6.18	2.82	24.53	0.00				



MICROCOPY RESOLUTION TEST CHART
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TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK NO.	IDENTIFICATION S/N-L-CP-PAS	REACTIVE CYCLE	ELECTROLYTE (G)	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	ELECTROLYTE-RETENTIONS (G)E/(G)SEP	ELECTROLYTE-RETENTIONS (G) / (CC)
63N	047 4 10 4	00545	26.30	1.11	2.57	4.13	0.00				
65N	108 1 04 1	03157	24.30	3.53	4.74	14.52	19.01	.0181	.0451	.97	.15
65N	109 1 04 2	05661	23.10	4.55	3.72	19.49	18.04	-.0020	.0522	.71	.11
65N	110 1 04 3	03157	25.30	5.03	3.82	19.88	19.83	.0141	.0818	1.28	.20
65N	133 1 04 4	04178	23.50	4.32	3.90	18.15	18.51	.0004	.0910	.44	.06
65N	134 1 04 5	04540	24.60	4.49	3.56	18.25	19.30	.0171	.0294	1.95	.22
65N	135 1 04 6	02953	0.00	0.00	0.00	0.00	0.00				
65N	136 1 04 7	01504	25.10	4.48	3.35	18.64	18.41	.0401	.0363	1.74	.23
65N	137 1 04 8	00771	24.30	1.95	8.65	8.04	19.08	.0472	.0729	1.75	.20
66N	142 1 04 8	00013	0.00	4.51	3.76	0.00	0.00	.0656	.0416	2.63	.29
67N	114 1 04 1	08242	26.50	3.14	5.18	11.86	20.83	.0293	.0839	2.04	.29
67N	115 1 04 2	09313	0.00	0.00	0.00	0.00	0.00				
67N	116 1 04 3	09313	0.00	0.00	0.00	0.00	0.00				
67N	151 1 04 4	14066	26.20	2.43	6.18	9.29	20.57	.0024	.1211	1.53	
67N	152 1 04 5	13662	24.80	2.89	5.58	10.77	21.04	-.0344	.1818	3.00	
67N	153 1 04 6	06876	25.40	3.91	4.18	15.38	19.87	.0120	.0657	2.56	
67N	154 1 04 7	04500	25.80	4.04	4.56	15.67	20.21	.0344	.0514	2.47	
67N	155 1 04 8	02253	25.20	4.34	3.81	17.22	19.70	.0307	.0598	2.27	.18
68N	117 1 04 1	00524	0.00	4.84	4.14	0.00	0.00	.0393	.0445	1.41	.17
68N	118 1 04 2	00472	0.00	4.71	4.04	0.00	0.00	.0317	.0394	1.33	.17
68N	119 1 04 3	00524	0.00	1.48	5.55	0.00	0.00	.0341	.0584	1.63	.26
68N	156 1 04 4	00955	0.00	6.34	3.34	0.00	0.00	.0364	.0281	.99	.13
68N	157 1 04 5	00955	0.00	4.35	4.03	0.00	0.00	.0230	.0424	1.21	.14
68N	158 1 04 6	00300	26.40	4.95	4.06	18.74	20.63	.0218	.0531	1.81	.23
68N	159 1 04 7	00200	23.90	4.25	3.90	17.76	18.80	.0474	.0599	2.17	.24
68N	160 1 04 8	00100	23.50	4.20	3.81	17.89	18.53	.0574	.0695	2.35	.27
69N	120 1 04 1	00592	26.70	3.62	4.75	13.55	20.96	.0304	.0823	2.42	.34
69N	121 1 04 2	00592	24.70	3.78	4.00	15.31	19.42	.0413	.0707	1.88	.30
69N	122 1 04 3	00172	0.00	3.74	3.64	0.00	0.00	.1220	.0366	1.93	.21
69N	161 1 04 4	00148	0.00	7.00	3.78	0.00	0.00	.0901	.0539	2.24	.26
69N	162 1 04 5	00148	0.00	7.22	3.69	0.00	0.00	.0858	.0521	2.59	.30
69N	163 1 04 6	00148	0.00	5.35	3.05	0.00	0.00	.0951	.0584	2.67	.31
69N	164 1 04 7	00172	0.00	5.93	3.63	0.00	0.00	.0868	.0502	2.24	.29
69N	165 1 04 8	00502	0.00	0.00	0.00	0.00	0.00				
70N	123 1 04 1	00694	27.10	3.12	5.39	11.50	21.14	.0093	.0553	2.18	
70N	126 1 04 2	01512	28.30	3.88	4.60	13.70	22.03	.0064	.0359	1.45	
70N	127 1 04 3	00684	0.00	0.00	0.00	0.00	0.00				
70N	166 1 04 4	01512	0.00	4.87	3.77	0.00	0.00	.0176	.0310	1.22	.15
70N	167 1 04 5	01512	0.00	4.67	3.94	0.00	0.00	.0175	.0187	1.39	.20
70N	168 1 04 6	01201	48.30	4.69	3.74	9.70	37.59	.0260	.0403	1.44	.14

TABLE [illegible] ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK NO.	IDENTIFICATION S/N-L-CP-P-CS	[illegible]	[illegible]	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	CELL KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	PATCH-TEST ELECTROLYTE-RETENTIONS (G)E/(G)SEP	PATCH-TEST ELECTROLYTE-RETENTIONS (G) / (CC)
70N	169 1 04 1	[illegible]	[illegible]	3.94	3.33	0.00	0.00	.0356	.0497	1.51	.16
70N	170 1 04 2	[illegible]	0.00	5.14	3.25	0.00	0.00	.0444	.0433	1.73	.19
71N	129 1 04 1	01631	27.60	[illegible]	5.95	11.27	21.49	.0011	.0615	.03	
71N	129 1 04 2	01636	[illegible]	[illegible]	[illegible]	11.52	22.45	-.0002	.0616	1.17	
71N	130 1 04 3	01133	[illegible]	3.27	5.70	11.46	21.61	.0174	.0307	1.57	.27
71N	171 1 04 4	01433	[illegible]	[illegible]	5.[illegible]	13.72	20.74	-.0045	.0539	.52	
71N	172 1 04 5	01431	[illegible]	[illegible]	[illegible]	11.74	22.07	-.0043	.0506	.88	
71N	173 1 04 6	01357	[illegible]	4.[illegible]	5.01	15.25	21.80	.0020	.0508	2.22	.02
71N	176 1 04 7	01541	27.70	3.93	5.29	14.41	21.60	-.0010	.0728	1.46	
71N	177 1 04 8	00752	25.80	4.18	3.81	16.19	20.19	.0337	.0560	1.97	.24
72N	131 1 04 1	01351	0.00	4.47	4.97	0.00	0.00	.0298	.0815	2.10	.25
72N	132 1 04 2	01717	0.00	4.33	4.83	0.00	0.00	.0305	.0421	1.51	.19
72N	178 1 04 4	01717	4.20	4.07	5.26	15.53	20.47	.0283	.0439	1.53	.13
72N	179 1 04 3	01355	[illegible]	3.51	6.21	0.00	0.00	.0411	.0485	2.24	.28
72N	191 1 04 5	01717	26.70	4.02	4.99	15.05	20.87	.0238	.0507	1.60	.16
72N	192 1 04 6	00149	0.00	4.91	3.37	0.00	0.00	.0712	.0491	1.91	.26
72N	193 1 04 7	00101	0.00	5.62	2.44	0.00	0.00	.0697	.0531	1.91	.23
72N	194 1 04 8	00750	0.00	5.06	3.11	0.00	0.00	.0795	.0608	2.23	.27
73N	180 1 04 1	02222	26.60	3.69	4.57	13.86	20.85	.0298	.0702	1.84	.21
73N	181 1 04 2	03501	27.00	3.94	4.33	14.60	21.00	.0026	.0252	1.61	
73N	182 1 04 3	03501	27.63	4.42	3.57	16.03	21.44	-.0011	.0289	.96	
73N	195 1 04 4	03501	22.70	3.33	5.49	14.56	17.67	.0086	.0206	1.25	
73N	196 1 04 5	03501	27.60	3.35	5.42	12.14	0.00	-.0093	.0513	0.00	
73N	197 1 04 6	00867	27.30	4.12	4.17	15.08	21.36	.0251	.0478	2.01	.21
73N	198 1 04 7	00624	24.80	3.93	4.26	15.83	19.49	.0399	.0663	1.91	.24
73N	202 1 04 8	00472	26.30	3.69	4.50	13.72	21.15	.0450	.0687	2.44	.27
74N	183 1 04 1	01196	26.10	3.34	4.68	12.81	20.55	.0717	.0892	2.43	.30
74N	185 1 04 2	01195	26.40	3.06	5.51	11.36	21.18	.0317	.1097	2.51	.29
74N	187 1 04 3	01751	28.10	1.92	7.12	6.83	22.01	.0192	.0712	2.40	.25
74N	203 1 04 4	01808	27.60	3.31	5.68	11.38	21.41	.0119	.0747	2.81	
74N	204 1 04 5	01811	27.20	3.09	5.75	11.38	21.29	.0141	.0752	1.93	.23
74N	205 1 04 6	00375	23.50	4.39	4.53	18.70	18.45	.0421	.0570	2.76	.38
74N	206 1 04 7	03250	20.60	4.28	3.02	20.76	16.21	.0618	.0568	2.16	.28
74N	207 1 04 8	00141	25.40	3.92	4.19	15.42	19.99	.0602	.0717	2.23	.32
75N	002 1 01 4	[illegible]	23.50	2.42	3.39	10.30	19.59	.0067	.0353	1.21	.12
75N	003 1 01 5	02496	23.50	1.98	3.56	8.42	19.59	.0059	.0308	1.68	
75N	004 1 01 6	02250	25.00	2.31	3.66	10.04	19.21	.0067	.0430	1.33	.15
75N	005 1 01 7	01505	23.20	2.05	4.32	8.84	19.45	.0120	.0665	1.56	.19
75N	006 1 01 8	00750	19.10	2.07	4.08	10.82	16.00	.0131	.0432	2.00	.15
75N	010 1 01 1	02595	31.30	2.62	3.38	8.36	26.00	-.0000	.0333	1.00	.10
75N	011 1 01 2	01335	24.00	2.30	3.72	9.58	20.08	.0030	.0577	1.40	.22

TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK NO.	IDENTIFICATION S/N-L-GRP-POS	REMOVAL CYCLE	ELECTROLYTE WEIGHT (G)	KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	SEPARATOR K2CO3 (G)	ELECTROLYTE-RETENTIONS (G)E/(G)SEP	(G) / (CC)
75N	012 1 01	3	01535 22.90	2.26	3.68	9.89	19.21				
76N	228 1 07	1	01202 24.60	6.21	4.56	21.71	21.00	.0070	.0685	1.99	.23
76N	229 1 07	2	01663 27.40	7.23	3.87	24.18	20.17	.0549	.0422	1.55	.18
76N	231 1 07	3	01115 27.70	7.29	3.55	24.31	20.24	.0372	.0341	1.10	.11
76N	232 1 07	4	01669 0.00	2.85	10.44	0.00	0.00	.0224	.0486	1.08	.11
76N	233 1 07	5	01669 27.50	6.98	4.22	25.39	20.11	.0619	.0497	1.62	.23
76N	234 1 07	6	00876 27.50	7.05	4.11	25.67	20.13	.0370	.0423	1.02	.13
76N	235 1 07	7	00623 27.90	6.91	4.38	24.78	20.39	.0405	.0416	1.60	.14
76N	236 1 07	8	00428 25.30	6.90	3.95	27.29	18.61	.0326	.0344	1.44	.16
77N	014 1 02	4	01909 0.00	4.15	4.32	0.00	0.00	.0735	.0537	1.79	.14
77N	015 1 02	5	01909 0.00	3.97	4.60	0.00	0.00	.0210	.0502	1.52	.05
77N	016 1 02	6	01594 24.80	3.46	4.99	13.95	19.36	.0147	.0424	1.00	.14
77N	017 1 02	7	01111 25.70	3.56	4.95	13.45	20.05	.0156	.0378	1.50	.14
77N	018 1 02	8	00615 25.10	3.40	4.88	13.55	19.64	.0152	.0479	1.45	.09
77N	021 1 02	3	01909 0.00	4.25	4.88	0.00	0.00	.0242	.0527	1.71	.15
77N	022 1 02	2	01909 0.00	4.71	4.20	0.00	0.00	.0185	.0374	1.13	.15
77N	026 1 02	1	01909 0.00	4.38	4.73	0.00	0.00	.0300	.0542	1.46	.17
78N	053 1 06	4	02354 0.00	3.44	4.61	0.00	0.00	.0206	.0420	1.27	.12
78N	054 1 06	5	02368 26.80	3.29	4.28	12.23	20.89	.0229	.0212	1.36	
78N	055 1 06	6	00748 23.40	4.34	3.76	18.55	18.34	.0091	.0342	1.32	
78N	057 1 06	7	00509 0.00	4.22	3.36	0.00	0.00	.0332	.0623	1.58	
78N	058 1 06	8	00251 38.00	4.15	3.36	10.92	29.68	.0608	.0376	1.59	.18
78N	064 1 06	1	02367 26.40	3.92	4.44	14.85	20.62	.0668	.0419	1.86	.17
78N	065 1 06	2	02345 30.10	3.13	5.39	10.41	23.41	.0169	.0600	1.34	.18
78N	066 1 06	3	02354 25.00	3.28	5.21	13.13	19.44	-.0032	.0468	.92	.16
79N	027 1 03	4	03679 21.20	2.43	5.13	11.48	16.50	-.0112	.0529	1.22	.09
79N	028 1 03	5	03732 19.70	3.48	4.93	17.66	15.32	0.0008	0.0000	.96	
79N	030 1 03	6	01463 23.70	-.19	6.30	-.76	18.55	-.0015	.0316	.63	
79N	031 1 03	7	01112 22.30	1.25	7.20	5.59	17.36	.0210	.0595	1.42	.08
79N	032 1 03	8	00580 19.80	3.45	4.79	17.41	15.52	.0084	.0326	.74	.16
79N	035 1 03	3	01480 0.00	2.58	5.38	0.00	0.00	.0366	.0507	1.30	.08
79N	036 1 03	2	03311 0.00	2.38	5.23	0.00	0.00	.0075	.0440	.93	.16
79N	037 1 03	1	02346 0.00	4.20	5.59	0.00	0.00	-.0025	.0382	.74	.11
80N	039 1 05	4	02320 46.30	4.61	4.15	9.95	36.11	.0250	.0466	1.34	.10
80N	040 1 05	5	02468 0.00	6.21	2.67	0.00	0.00				.16
80N	041 1 05	6	01425 0.00	5.89	3.24	0.00	0.00	.0353	.0560	1.64	.20
80N	042 1 05	7	00953 0.00	5.40	4.19	0.00	0.00	.0488	.0502	1.86	.23
80N	043 1 05	8	00511 0.00	4.30	4.25	0.00	0.00	.0485	.0513	2.03	.25
80N	049 1 05	1	03240 28.60	3.42	5.79	11.95	22.38	.0623	.0498	2.26	.32
80N	051 1 05	2	02320 30.20	5.85	3.83	19.37	23.47	.0666	.0775	2.48	.32
80N	052 1 05	3	02339 0.00	4.85	4.77	0.00	0.00	.0088	.0890	2.22	
								.0465	.0776	1.96	.27
								.0477	.0723	2.03	.31

TABLE V-5 ELECTROLYTE-SEPARATOR-ANALYSIS (continued)

PACK I.D.	IDENTIFICATION S/N-L-GRP-POS				REMOVAL CYCLE	ELECTROLYTE [illegible] (G)	CELL EXTRACT KOH (G)	CELL EXTRACT K2CO3 (G)	CELL KOH CONC	CELL KOH AMOUNT (CC)	PATCH-TEST SEPARATOR KOH (G)	PATCH-TEST SEPARATOR K2CO3 (G)	PATCH-TEST ELECTROLYTE-RETENTIONS (G)E/(G)SEP	PATCH-TEST ELECTROLYTE-RETENTIONS (G) / (CC)
81N	189	1	04	1	03014	[illegible]	3.23	4.65	12.70	19.77	.0019	.0323	1.44	
81N	190	1	04	2	01[illegible]	[illegible]	3.51	5.60	13.46	20.48	.0331	.0750	1.82	.23
81N	208	1	04	4	03055	[illegible]	0.00	0.00	0.00	0.00				
81N	209	1	04	5	03[illegible]	[illegible]	0.00	0.00	0.00	0.00				
81N	210	1	04	6	01[illegible]	[illegible]	4.39	4.05	0.00	0.00	.0378	.0613	2.06	.25
81N	211	1	04	7	01[illegible]	[illegible]	4.72	3.46	0.00	0.00	.0527	.0564	2.15	.31
81N	212	1	04	8	01502	[illegible]	0.00	0.00	0.00	0.00				
81N	224	1	04	3	01[illegible]	[illegible]	3.59	4.64	0.00	0.00	.0437	.0858	2.30	.36
82N	291	1	04	1	00678	24.[illegible]	4.06	3.33	19.53	19.56	.0575	.0533	1.84	.31
82N	292	1	04	2	00678	25.00	4.86	3.46	19.45	19.63	.0525	.0506	1.75	.29
82N	295	1	04	5	00678	24.30	4.45	3.66	20.38	19.13	.0635	.0560	2.19	.35
83N	071	1	08	6	00000	23.40	5.15	2.37	26.28	17.67	.0262	.0237	.75	.01
83N	073	1	08	5	00000	23.10	5.89	2.57	25.50	17.53	.0568	.0353	1.24	.01
83N	093	1	08	2	00000	25.50	4.85	3.88	19.00	0.00	.0348	.0457		
84N	084	1	08	7	00000	24.[illegible]	5.78	2.64	23.69	18.42	.0318	.0238	.79	
86N	089	1	08	6	00000	25.10	5.18	3.59	20.64	18.92	.0184	.0221	.68	
87N	219	1	04	1	00000		5.74	2.31			.0954	.0467	2.27	.30
87N	220	1	04	2	00000		6.13	1.31			.0960	.0446	2.26	.28
87N	221	1	04	3	00000		5.64	2.68			.0978	.0457	1.74	.26
89N	216	1	01	1	00000									
89N	217	1	01	2	00000									
89N	218	1	01	3	00000									
90N	237	1	01	1	00000	25.40	8.12	2.15	31.96	18.74	.1224	.0358	2.39	.27
90N	238	1	01	2	00000	25.40	7.98	2.62	31.44	18.76	.1336	.0377	2.21	.24
90N	239	1	01	3	00000	25.50	7.89	2.76	30.94	18.85	.1408	.0448	2.25	.27
91N	059	1	06	1	00000	22.80	5.49	2.23	24.08	17.94	.0823	.0412	1.84	.25
91N	060	1	06	2	00000	23.20	5.26	2.30	22.69	18.26	.0821	.0450	1.99	.25
91N	061	1	06	3	00000	22.[illegible]	5.05	2.97	22.03	18.06	.0694	.0651	2.16	.30
92N	044	1	05	1	00000		6.48	2.84			.1245	.0710	2.74	.40
92N	045	1	05	2	00000		7.28	2.25			.1242	.0704	2.53	.35
92N	046	1	05	3	00000		6.46	2.88			.1194	.0752	3.11	.40

SECTION VI

DATA ANALYSIS

The main objective of the Accelerated Test Program was to produce cell failures under stressful conditions and to relate these failures to failures under normal space flight conditions. To achieve this goal nickel-cadmium spacecraft cells were tested. The majority of the cells were cycled until failure under stress levels of the following test parameters: depth of discharge, temperature, charge rate, discharge rate and percent recharge. The remainder of the cells were either cycled for a specified length of time (scheduled removals) or were stored at a specified temperature storage condition. At the conclusion of the cycling tests, many of the cells were torn down for chemical and physical analysis. In Section VI.A the statistical analyses of the cycling data is presented. The analyses of the chemical and physical data is presented in Section VI.B.

There are four broad areas of concern in the analyses of the Accelerated Test Program data. First, which test conditions are effective in accelerating (i.e., shortening) the life of a cell? Are there any combinations of stresses which are particularly detrimental to the life of the cell? Is there a quantitative measure of the effect on the cycle life of a cell of increasing the stress level of a particular test parameter? These concerns are addressed in Section VI.A.1 and VI.A.2 as part of the discussion of the results of an Analysis of Variance performed on the cycling data and in the Pack Average Summaries.

The second area of concern is the ability to use the results of the accelerated test cycling data to predict the time to failure of cells tested under normal stress conditions. Towards this end, a set of mathematical equations describing the relationship between the cycle life of a cell and the stress levels of the test parameters is developed. These equations are then used to predict the average cycle life of a cell tested under normal or near normal test conditions. Since the Accelerated Test Program includes four cell packs which are still cycling at normal test conditions, only preliminary judgments can be made on the prediction techniques. A discussion of the mathematical equations and the prediction technique is found in Section VI.A.3 and VI.A.4 under Multiple Linear Regression and Non-Linear Regression.

The third area of concern is the problem of finding a performance characteristic which can be measured after a minimum of cycling time and can be used to distinguish the cells having long cycle lives from the cells having short cycle lives under the same test conditions. Early in the program, attempts were made to evaluate several proposed prediction techniques. These techniques (TiBAR, Hysteresis Loop and Charge/Discharge Curve Fitting) were unsuccessful in discerning the individual cell characteristics. This was due, in part, to an insufficient amount of data and the manner in which the techniques were applied. The results of these analyses are presented in Section VI.A.5 - VI.A.6 under the names of the various techniques.

The fourth area of concern is the effect that the stress conditions have on the cell. Do the stress conditions cause physical and chemical changes within the cell which can be related to the level of the stress condition? To what extent, are the stress conditions causing alternate failure mechanisms? These questions are central to the concept of accelerated life testing? This part of the analyses of the accelerated test data is incomplete. Preliminary work is referenced and summarized in Section VI.B.

A. ANALYSIS OF COMPOSITE DESIGN

1. Analysis of Variance

Analysis of variance is a statistical procedure used to test the results of a properly designed experiment to determine if the differences observed in the results are due to the effects of test parameters or to random variation of the test samples. For example, are the cycle life differences observed between the cells cycled at high and low temperatures due to the effect of temperature as a stress condition or due to random fluctuation in the test data. In this analysis main effects and two-way interactions were tested. A significant main effect means that the measured response is caused by the different values of the test parameter with a set probability (significance level) of being wrong (for example 5%). When declaring an effect significant, the significance level is the probability that the observed difference was simply caused by random sampling error. A two-way interaction between two parameters exists when the effect of the first parameter depends on the level of the second parameter. Several analysis of variance tests were performed on the factorial data of the test design, thus, enabling the selection of the "best" composite set of significant factors that determines the life of the cells. Four failure definitions, response variables, were used: cycles to 0.0 volts, hours to 0.0 volts, cycles to 1.0 volts, and hours to 1.0 volts. In determining the composite set, a factor that was significant as an interaction was also included as a main effect. This was the case for the variables precharge ampere-hours and concentration of electrolyte.

The results of four ANOVAS are summarized in Table VI-1. The variables and variable combinations listed in Table VI-1 are those factors which had a significant effect (significance level .05) on the cycle life of a cell. For example, DOD appears on the cycles to 0.0 Volts list. This means that the average cycle life (Cycles to 0.0 Volts) of cells cycling at the low level of depth of discharge (40%) differed significantly from the average cycle life of cells cycling at the high level of depth of discharge (80%). As another example, notice that T x DOD appears on the Cycles to 0.0 Volts list. This means that the difference in the average cycle life of cells cycled at high and low DOD depends on the temperature at which the cells were cycles.

TABLE VI-1 "BEST" COMPOSITE SET OF SIGNIFICANT FACTORS

CYCLES TO 0.0 Volts	HOURS TO 0.0 Volts	CYCLES TO 1.0 Volts	HOURS TO 1.0 Volts
T	T	T	T
DOD	DOD	DOD	DOD
CR	CR	CR	CR
DR	DR	DR	DR
CHG	CHG	CHG	CHG
	PKOH	PKOH	PKOH
PC	PC	PC	PC
T X DOD	T X DOD	T X DOD	T X DOD
T X CR	T X CR		T X CR
			T X DR
		T X PKOH	
DOD X CR	DOD X CR	DOD X CR	
DOD X DR	DOD X DR		
DOD X CHG			
CR X DR	CR X DR	CR X DR	CR X DR
	CR X CHG		
DR X CHG		DR X CHG	DR X CHG
		DR X PC	DR X PC
CHG X PC	CHG X PC		

A review of Table VI-1 provides a comparison of the four failure definitions:

1. In all cases the variables temperature (T), depth-of-discharge (DOD), charge rate (CR), discharge rate (DR), percent recharged (CHG), and precharge (PC) were significant.

2. The variable concentration of electrolyte (PKOH) was significant in all cases except cycles to 0.0 volts.

3. The variable amount of electrolyte (AKOH) was not significant in any case.

4. In all cases the interaction of temperature-with-depth of discharge (T X DOD) and charge rate-with-discharge rate (CR X DR) was significant.

The following interactions were significant in three of the four cases; temperature-with-charge rate (T X CR) except for cycles to 1.0 volts, depth of discharge-with-charge rate (DOD X CR) except for hours to 1.0 volts, and discharge rate-with-percent recharged (DR X CHG) except for hours to 0.0 volts.

Other significant interactions were:

1. For cycles to 0.0 volts; depth of discharge-with-discharge rate (DOD X DR), depth of discharge-with-percent recharged (DOD X CHG), and percent recharged-with-precharge (CHG X PC).

2. For hours to 0.0 volts; depth of discharge-with-discharge rate (DOD X DR), charge rate-with-percent recharged (CR X CHG) and percent recharged-with-precharge (CHG X PC).

3. For cycles to 1.0 volt; temperature-with-concentration of electrolyte (T X PKOH) and discharge rate-with precharge (DR X PC).

4. For hours to 1.0 volts; temperature-with-discharge rate (T X DR) and discharge rate-with-precharge (DR X PC).

Procedure Used in Analysis of Variance. The original design of the factorial portion of the test matrix was a 1/4 replication of a 2^8 factorial, i.e., two levels of each of eight factors with 1/4 of the combinations filled as shown in Figure VI-1. For each point in the design there is one pack with five cells in each pack. The defining contrast is I=ABCEH=ABDEG=CDEFGH, where:

A =	Temperature °C	(T)
B =	DOD %	(DOD)
C =	Charge Rate Amperes	(CR)
D =	Discharge Rate Amperes	(DR)
E =	Percent Charged %	(CHG)
F =	Concentration of Electrolyte %	(PKOH)
G =	Amount of Electrolyte cc	(AKOH)
H =	Precharge Ampere-hours	(PC)
I =	Mean or Identity (by definition)	

The 1/4 replication is the minimum design that can be used to perform an analysis which will have a good test for all main effects and all two-way interactions. Therefore, the analysis is weakened if any of these treatment combinations are missing. For various reasons, several treatment combinations are missing: the temperatures of Packs 36N and 24N were switched; Pack 20N was cycled with the same environmental factors as Pack 9N; all cells of pack 51N failed because of hardware

FIGURE VI-1 FRACTIONAL FACTORIAL TEST MATRIX

NOTE: In the composite design Packs 20N, 24N and 36N were to be tested at the positions shown, but the actual parameters were those of positions A, B and C respectively.

					TEMPERATURE °C															
					30°								50°							
					% DOD 40				% DOD 80				% DOD 40				% DOD 80			
					CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C	
% RECHARGE	% KOH	CC KOH	PC		DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C
				CYCLE PERIOD HRS.	2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00	2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00
200	34	CC KOH	20.5 PC	3	5N							(20N)				49N	40N			
200	34	CC KOH	20.5 PC	2.5			56N			33N				4N					21N	
200	34	CC KOH	18.5 PC	3		64N					41N				12N			29N		
200	34	CC KOH	18.5 PC	2.5				13N	28N				57N							48N
200	26	CC KOH	20.5 PC	3		47N					53N				27N			14N		
200	26	CC KOH	20.5 PC	2.5				30N	11N				42N							63N
200	26	CC KOH	18.5 PC	3	22N							3N				34N	55N			
200	26	CC KOH	18.5 PC	2.5			39N			50N				19N					6N	
				CYCLE PERIOD HRS.	1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76	1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76
140	34	CC KOH	20.5 PC	3			35N	(A)		54N				23N					2N	
140	34	CC KOH	20.5 PC	2.5	18N							7N				33N	51N			
140	34	CC KOH	18.5 PC	3				26N	15N				46N							59N
140	34	CC KOH	18.5 PC	2.5		43N					62N				31N			10N		
140	26	CC KOH	20.5 PC	3				9N	32N				61N							44N
140	26	CC KOH	20.5 PC	2.5		60N					45N				16N			25N		
140	26	CC KOH	18.5 PC	3			52N			37N				8N					17N	
140	26	CC KOH	18.5 PC	2.5	1N				(C)			(24N)				53N	(36N)			(B)

problems; and for the combination of 80% DOD and C/2 charge rate, the charge efficiency was too low to sustain long term cycling. Therefore, it was questionable whether Packs 10N, 14N, 25N, 29N, 40N, and 55N should be used in an ANOVA. The proper analysis for the original design was a split plot analysis with the physical factors making up the whole plot while the environmental factors made up the split plot. The error term used to test the environmental factors was to be estimated by replication of the center point. However, the loss of one of the center point packs due to equipment failure, forced a remission of this type analysis.

In view of these problems, the challenge was to determine what types of analyses could be done to gain the most information from the ANOVA. The following steps were taken:

All pressure failures and all failures caused by hardware problems were treated as censored readings. A censored reading is one that was removed from test prior to reaching the failure criteria. Censored readings were deleted for all analysis of variance. This caused unequal replication within treatment combinations. The multi-variate analysis of variance (MANOVA) computer program contained in Statistical Package for Social Studies (SPSS) was used because it can handle both unequal replication and missing treatment combinations.

An ANOVA was run using all data except for packs 20N, 24N, 36N, and 51N. This ANOVA was on the complete 1/4 replication of the 2^8 design using the actual values for the questionable packs 40N, 29N, 14N, 55N, 10N, and 25N.

The only treatment combinations missing for the 2C charge rate are 20N and 24N. Therefore, an ANOVA was run on the half of the design where the charge rate is 2C. This is a 1/4 replication of a 2^7 design with the defining contrast I = ABEH = ABDFG = DEFGH. This provided a test for the remaining seven main effects and some of the two-way interactions. Some of the two-way interactions are confounded. This means that the only test available for these interactions can declare that one or the other or both are significant but cannot determine which one. The following interactions are confounded AE = BH, AB = EH, and BE = AH.

For the low level of DOD (40%) there are no missing treatment combinations. Therefore, an ANOVA was also run using the half of the design where DOD was 40%. This is also a 1/4 replication of a 2^7 design with the defining contrast this time being I = ACEH = ADFG = CDEFGH and the interactions which are confounded are AC = EH, AE = CH, CE = AH, AF = DG, DF = AG, and AD = FG.

The last two ANOVAs were run to see if greatly different results were obtained by including or excluding the questionable packs 40N, 29N, 14N, 55N, 10N, and 25N.

All three of the above ANOVAs were performed to analyze each of the four failure criteria and their natural logarithm. The logarithm were used to help improve homogeneity of variances. A total of 24 ANOVAs were performed.

The results of the above ANOVAs indicated that the error term used, which was the within pack variation, might be too small for proper analysis. This was indicated by the fact that most of the main effects and two-way interactions were significant. This indicates that there might be a larger pack-to-pack variation than the within pack variations. However, no data was available to obtain a measurement of this error. An analysis of the error term was performed by dividing the total sum of squares into three groups: the sum of squares due to main effects and two-way interactions, the sum of squares within pack, and the remainder which was due to the higher order interactions and/or the pack-to-pack variation. The mean square of the remainder was compared to the within pack mean square. Since this mean square of the remainder was much larger, the decision was made that there was a pack-to-pack variation and the mean square remainder would be the proper error term. Remember, the basic assumption of the composite design is that the high order interactions are negligible. Therefore, the conclusion is that the remainder is a measure of the pack-to-pack variation. The remainder mean square was used for all tests in the ANOVAs.

The results of all of the ANOVAs are presented in Tables VI-2 and VI-3. The tables include all main effects and two-way interactions. Two levels of significance, .01 and .05, were used. If an effect was significant then the lowest significance level is presented in the table. A dash indicates no test for that effect and a blank indicates that the effect was not significant at either of the two levels. Within a column, confounding is depicted by enclosing the two significance levels by the same figure. A composite set for each of the four criteria was formed and is presented in Table VI-1.

TABLE VI-2 ANOVA SIGNIFICANCE LEVELS
Failure at 0.0 Volts

	CYC ALL DATA	CYC LOW DOD	CYC HIGH CR	HOURS ALL DATA	HOURS LOW DOD	HOURS HIGH CR	LN CYC ALL DATA	LN CYC LOW DOD	LN CYC HIGH CR	LN HOURS ALL DATA	LN HOURS LOW DOD	LN HOURS HIGH CR
T	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
DOD	.01	-	.01	.01	-	.01	.01	-	.01	.01	-	.01
CR			-	.01	.01	-	.01		-		.01	-
DR	.05		.01	.05				.05	.01	.01		
CHG	.01	.01	.01			.01	.05	.01	.01			.01
PKOH						.05			.05			.05
AKOH												
PC												
T X DOD	.01	-	.05		-	.05	.01	-		.01	-	
T X CR			-	.01	.05	-	.01		-	.01		-
T X DR												
T X CHG												
T X PKOH												
T X AKOH						.05						
T X PC												
DOD X CR		-	-	.05	-	-	.01	-	-	.01	-	-
DOD X DR		-			-		.05	-		.05	-	
DOD X CHG	.01	-			-			-			-	
DOD X PKOH		-			-			-			-	
DOD X AKOH		-			-			-			-	
DOD X PC		-			-			-			-	
CR X DR			-			-	.01		-	.05		-
CR X CHG			-			-			-	.05		-
CR X PKOH			-			-			-			-
CR X AKOH			-			-			-			-
CR X PC			-			-			-			-
DR X CHG			.05									
DR X PKOH												
DR X AKOH												
DR X PC												
CHG X PKOH												
CHG X AKOH												
CHG X PC					.05	.05	.01			.01		
PKOH X AKOH												
PKOH X PC												
AKOH X PC												

TABLE VI-3 ANOVA SIGNIFICANCE LEVELS
Failure at 1.0 Volts

	CYC ALL DATA	CYC LOW DOD	CYC HIGH CR	HOURS ALL DATA	HOURS LOW DOD	HOURS HIGH CR	LN CYC ALL DATA	LN CYC LOW DOD	LN CYC HIGH CR	LN HOURS ALL DATA	LN HOURS LOW DOD	LN HOU HIGH C
T	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
DOD	.01	-	.01	.01	-	.01	.01	-	.01	.01	-	.01
CR	.01	.01	-	.01	.01	-	.01	.01	-			-
DR	.01	.01	.05	.01	.01	.01	.01	.01	.05	.01	.01	.01
CHG	.01	.05	.05									
PKOH	.05		.01			.05	.05			.05		
AKOH												
PC												
T X DOD	.01	-	.01	.01			.05			.05		
T X CR			-	.01	.05	-	.01	.05	-	.01	.05	-
T X DR				.05			.01	.05		.01	.05	
T X CHG												
T X PKOH	.05	.05	.05									
T X AKOH												
T X PC												
DOD X CR	.01	-	-		-	-		-	-		-	-
DOD X DR		-			-		.01	-		.01	-	
DOD X CHG		-			-			-			-	
DOD X PKOH		-			-			-			-	
DOD X AKOH		-			-			-			-	
DOD X PC		-			-			-			-	
CR X DR	.05		-	.01		-	.01	.05	-	.01		-
CR X CHG			-			-			-			-
CR X PKOH			-			-			-			-
CR X AKOH			-			-			-			-
CR X PC			-			-			-			-
DR X CHG	.01	.05		.05								
DR X PKOH												
DR X AKOH		.05		.05								
DR X PC	.01	.01	.05	.05								
CHG X PKOH												
CHG X AKOH												
CHG X PC			.01		.05			.05			.05	
PKOH X AKOH												

2. Pack Average Summaries

In order to further understand the results of the analysis of variance tests, several tables of pack averages have been generated. The tables can be used to determine the extent of the significance of a test variable on the cycle life of a cell. The summary tables presented here are: the pack averages (Figures VI-2 and 3, and Table VI-4), the mean time to failure of cells cycling at the low and high level of a variable (Table VI-5), and the mean time to failure of cells cycling at combinations of high and low levels of two variables (Table VI-6).

a. Pack Averages. The pack averages were found by using Kaplan-Meier Statistics for data with censored readings. To do this, first, let t_1, t_2, ...t_N be the ordered times and censored readings. Then

$$\text{pack average} = t_1 + p_1 (t_2-t_1) + p_2 (t_3-t_2) + \ldots + p_{N-1}(t_N-t_{N-1})$$

$$\text{where } p_i = \frac{(N-X_1)\ (N-1-X_2)\ldots(N-i+1-X_i)}{N\ (N-1)\ \ldots\ (N-i+1)}$$

and $X_i = 0$ if t_i is a censored reading
$= 1$ if t_i is a true failure

Within a pack, this equation deletes a censored reading that was smaller than the first true failure and weights a censored readings larger than the first failure in relation to the true failures. The observed failure times of Table IV-9 were used to determine the pack averages presented in Figures VI-2 and VI-3. In Table VI-4, the pack averages for the star points and center point are also given.

FIGURE VI-2 FRACTIONAL FACTORIAL MATRIX PACK AVERAGES TO 0.0 VOLTS

NOMENCLATURE
Pack No. N
Average Life in Cycles
Average Life in Hours
*Run at Wrong Condition See Figure VI-1

% RECHARGE	% KOH	CC KOH	PC	TEMPERATURE °C 30°								50°							
				% DOD 40				% DOD 80				% DOD 40				% DOD 80			
				CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C		CHARGE RATE C/2		CHARGE RATE 2C	
				DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C	DISCHG RATE C	DISCHG RATE 4C
CYCLE PERIOD HRS.				2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00	2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00
200	34	20.5	3	5N – –											49N 3676 1838	40N 584 2336			
			2.5			56N 4926 3941			33N 2130 7244				4N 3266 5552					21N 446 713	
		18.5	3		64N 6353 10801					41N 666 1065				12N 2046 1637			29N 18 61		
			2.5				13N 8290 4145	28N 2317 9266				57N 2675 5350							48N 796 796
	26	20.5	3		47N 7537 12813					58N 1670 2672				27N 2664 2131			14N 30 103		
			2.5				30N 5600 2800	11N 2329 9316				42N 860 1719							63N 1030 1030
		18.5	3	22N 3050 6101							3N 1634 1634				34N 3181 1591	55N 432 1727			
			2.5			39N 7106 5685			50N 1690 5746				19N 2505 4258					6N 716 1145	
CYCLE PERIOD HRS.				1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76	1.52	1.22	0.68	0.38	3.04	2.44	1.36	0.76
140	34	20.5	3			35N 4676 3180	20N* 10848 4122		54N 1637 3994				23N 4614 5629					2N 929 1263	
			2.5	18N 8436 12822							7N 3007 2285				38N 6734 2559	51N 12 36			
		18.5	3				26N 10025 3809	15N 2971 9032				46N 3110 4728							59N 1556 1183
			2.5		43N 9460 11541					62N 2407 3273				31N 4349 2958			10N 17 41		
	26	20.5	3				9N 16773 6374	32N 2894 8797				61N 2349 3570							44N 2454 1865
			2.5		60N 8502 10372					45N 1408 1915				16N 5450 3706			25N 32 79		
		18.5	3			52N 7492 5094			37N 1289 3144				8N 3862 4712					17N 1320 1794	
			2.5	1N 10348 15729				36N* 1323 4022							53N 6062 2304				24N* 1937 1472

FIGURE VI-3 FRACTIONAL FACTORIAL MATRIX PACK AVERAGE TO 1.0 VOLTS

NOMENCLATURE
Pack No. ... N
Average Life in Cycles ...
Average Life in Hours ...
*Run at Wrong Condition See Figure VI-1

					TEMPERATURE °C													
					30°								50°					
					% DOD								% DOD					
					40				80				40				80			
					CHARGE RATE				CHARGE RATE				CHARGE RATE				CHARGE RATE			
					C/2		2C		C/2		2C		C/2		2C		C/2		2C	
					DISCHG RATE		DISCHG RATE		DISCHG RATE		DISCHG RATE		DISCHG RATE		DISCHG RATE		DISCHG RATE		DISCHG RATE	
					C	4C	C	4C	C	4C	C	4C	C	4C	C	4C	C	4C	C	4C
CYCLE PERIOD HRS.					2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00	2.00	1.70	0.80	0.50	4.00	3.40	1.60	1.00
% RECHARGE	% KOH	CC KOH	PC	3	5N - -											49N 2965 1482	40N 510 2039			
				2.5			56N 4923 3938			33N 229 777				4N 199 338					21N 442 708	
			18.5	3		64N 3571 6071					41N 663 1060				12N 2003 1602			29N 11 37		
				2.5				13N 4228 2114	28N 2272 9088				57N 2651 5302							48N 136 136
		26	20.5	3		47N 4516 7677					58N 1663 2660				27N 2660 2128			14N 21 72		
				2.5				30N 5074 2537	11N 2089 8357				42N 859 1718							63N 92 92
			18.5	3	22N 2767 5534							3N 1049 1049				34N 2606 1303	55N 402 1607			
				2.5			39N 6503 5202			50N 242 823				19N 412 700					6N 714 1142	
CYCLE PERIOD HRS.					1.52	1.22	0.63	0.33	3.04	2.44	1.36	0.76	1.52	1.22	0.63	0.33	3.04	2.44	1.36	0.76
	% KOH	CC KOH	PC	3			35N 4674 3178	20N* 9571 3637		54N 308 752				23N 148 181					2N 189 257	
				2.5	18N 7579 11520							7N 662 503				38N 1959 744	51N 10 30			
			18.5	3				26N 4600 1748	15N 2049 6228				48N 3079 4680							59N 94 71
				2.5		43N 2122 2588					62N 2405 3271				31N 4345 2955			10N 12 30		
		26	20.5	3				9N 7374 2802	32N 2772 8427				61N 2349 3570							44N 466 354
				2.5		60N 4870 5942					45N 1406 1912				16N 4335 2948			25N 25 61		
			18.5	3			52N 7482 5088			37N 555 1354				8N 375 458					17N 1320 1794	
				2.5	7N 10085 15333				36N* 1188 3610							53N 2850 1083				24N* 1009 767

TABLE VI-4 PACK AVERAGES

PACK	CYCLES		HOURS	
	0.0 Volts	1.0 Volts	0.0 Volts	1.0 Volts
1N	10348	10088	15729	15333
2N	929	139	1263	257
3N	1634	1049	1634	1049
4N	3266	199	5552	338
5N	-	-	-	-
6N	715	714	1145	1142
7N	3007	662	2285	503
8N	3862	375	4712	458
9N	16773	7374	6374	2802
10N	17	12	41	30
11N	2329	2089	9316	8357
12N	2046	2003	1637	1602
13N	8290	4228	4145	2114
14N	30	21	103	72
15N	2971	2049	9032	6228
16N	5450	4335	3706	2948
17N	1320	1320	1794	1794
18N	8436	7579	12822	11520
19N	2505	412	4258	700
20N	10048	9571	4122	3637
21N	446	442	713	708
22N	3050	2767	6101	5534
23N	4614	148	5629	181
24N	1937	1009	1472	767
25N	32	25	79	61
26N	10025	4600	3809	1748
27N	2664	2660	2131	2128
28N	2317	2272	9266	9088
29N	18	11	61	37
30N	5600	5074	2800	2537
31N	4349	4345	2958	2955
32N	2894	2772	8797	8427
33N	2130	229	7244	777
34N	3181	2606	1591	1303
35N	4676	4674	3180	3178
36N	1323	1188	4022	3610
37N	1289	555	3144	1354
38N	6734	1959	2559	744
39N	7106	6503	5685	5202
40N	584	510	2336	2039
41N	666	663	1065	1060

PACK	CYCLES		HOURS	
	0.0 Volts	1.0 Volts	0.0 Volts	1.0 Volts
42N	860	859	1719	1718
43N	9460	2122	11541	2588
44N	2454	466	1865	354
45N	1408	1406	1915	1912
46N	3110	3079	4728	4680
47N	7537	4516	12813	7677
48N	796	136	796	136
49N	3676	2965	1838	1482
50N	1690	242	5746	823
51N	12	10	36	30
52N	7492	7482	5094	5088
53N	6062	2850	2304	1083
54N	1637	308	3994	752
55N	432	402	1727	1607
56N	4926	4923	3941	3938
57N	2675	2651	5350	5302
58N	1670	1663	2672	2660
59N	1556	94	1183	71
60N	8602	4870	10372	5942
61N	2349	2349	3570	3570
62N	2407	2405	3273	3271
63N	1030	92	1030	92
64N	6353	3571	10801	6071
65N	4763	3427	5430	3907
66N	13	-	15	-
67N	13864	13863	5268	5268
68N	685	179	1301	339
69N	241	17	881	61
70N	1512	438	771	223
71N	1582	1582	3227	3227
72N	1717	14	1571	13
73N	3241	439	3112	422
74N	1806	426	2710	639
75N	2522	872	2874	994
76N	1558	779	1776	888
77N	1909	797	2176	909
78N	2357	812	2687	925
79N	3574	3471	4074	3957
80N	2630	610	2998	695
81N	3041	475	3467	542
82N	3803	1706	4335	1945

TABLE VI-5 MEAN TIME TO FAILURE AT INDICATED VARIABLE LEVEL

Variable	(Cycles to 0.0 Volts)		(Hours to 0.0 Volts)	
	Low Level	High Level	Low Level	High Level
Temperature	5210	2122	6847	2154
DOD	5972	1360	6241	2761
Discharge Rate	3310	4022	5109	3893
Charge Rate	3456	3876	6481	2521
% Recharge	4286	3046	4390	4612
% KOH	3740	3592	4418	4584
KOH (cc)	3598	3734	4431	4570
Precharge	3622	3710	4407	4595
Variable	**(Cycles to 1.0 Volts)**		**(Hours to 1.0 Volts)**	
	Low Level	**High Level**	**Low Level**	**High Level**
Temperature	**3470**	**1199**	**4680**	**1255**
DOD	**3887**	**782**	**4153**	**1781**
Discharge Rate	**2986**	**1683**	**4508**	**1427**
Charge Rate	**2108**	**2561**	**4133**	**1801**
% Recharge	**2561**	**2109**	**2856**	**3079**
% KOH	**2608**	**2061**	**3230**	**2705**
KOH (cc)	**2410**	**2259**	**3096**	**2839**
Precharge	**2349**	**2320**	**2919**	**3016**

Table VI-5 presents the overall means for each of the two levels of the fractional factorial, low and high, of the eight test parameters at each of the four response variables. These averages provide an indication of the change in average cell life between the low level and high level of a variable. For example, with a failure criteria of cycles to 0.0 volts, a change in temperature from the low level (30° C) to the high level (50° C) would reduce the life of the cell by approximately 3088 cycles, a significant reduction, where as a change in the precharge increases the life only 100 cycles. However, interactions of variables cause these differences to vary over the entire factorial matrix. Table VI-6 presents the two-way classification means for all combinations of low and high levels. An example will clarify this point.

For T X CR:

		T	
		Low (30° C)	High (50° C)
CR	Low	5379	1532
	High	5040	2713

By fixing the charge rate (CR) at the low level and changing the temperature (T) from 30° C to 50° C, a decrease of approximately 2847 cycles is expected. If the charge rate (CR) is held at the high level, and temperature is increased from 30° C to 50° C, then a decrease of 2227 cycles is expected. The conclusion is that the low charge rate-high temperature combination is particularly stressful to the cells.

TABLE VI-6 TWO WAY Classifications (MEAN TIME TO FAILURE)

Variable Combination	Cycles to 0.0 Volts at Indicated Variable Combination Levels				Hours to 0.0 Volts at Indicated Variable Combination Levels			
	High-High	High-Low	Low-High	Low-Low	High-High	High-Low	Low-High	Low-Low
T X DOD	657	3588	2063	8356	919	3390	4604	9091
T X DR	2490	1755	5555	4864	2100	2209	5686	8009
T X CR	2713	1532	5040	5379	1782	2527	3259	10436
T X CHG	1558	2687	4534	5885	1999	2310	7225	6470
T X PKOH	2181	2064	5004	5416	2305	2004	6862	6833
T X AKOH	2200	2045	5268	5152	2146	2163	6995	6700
T X PC	2052	2193	5369	5050	2260	2048	6930	6765
DOD X DR	1392	1328	6653	5291	2092	3430	5694	6788
DOD X CR	1562	1158	6191	5753	1682	3841	3359	9122
DOD X CHG	1163	1557	4929	7015	2935	2587	6289	6193
DOD X PKOH	1354	1365	5830	6114	2806	2716	6361	6120
DOD X AKOH	1423	1297	6044	5900	2873	2650	6268	6213
DOD X PC	1387	1333	6034	5911	2674	2848	6516	5965
DR X CR	4736	3309	3017	3602	2405	5381	2636	7582
DR X CHG	3116	4929	2976	3643	3908	3878	5316	4902
DR X PKOH	3981	4064	3204	3416	3974	3812	5193	5025
DR X AKOH	4321	3724	3146	3473	4166	3620	4975	5243
DR X PC	4172	3873	3249	3370	3854	3932	5336	4881
CR X CHG	2910	4843	3181	3730	2184	2858	7040	5922
CR X PKOH	3540	4213	3644	3267	2297	2744	6870	6093
CR X AKOH	3972	3781	3495	3416	2524	2517	6617	6346
CR X PC	3930	3823	3491	3420	2453	2588	6738	6225
CHG X PKOH	3184	2907	4000	4572	4884	4340	4283	4496
CHG X AKOH	3094	2998	4373	4199	4850	4374	4290	4489
CHG X PC	3174	2918	4247	4326	4930	4294	4261	4519
PKOH X AKOH	3618	3566	3849	3631	4812	4355	4329	4508
PKOH X PC	3476	3708	3945	3535	4622	4545	4568	4268
AKOH X PC	4078	3390	3343	3854	4998	4143	4193	4670

TABLE VI-6 (continued)

Variable Combination	Cycles to 1.0 Volts at Indicated Variable Combination Levels				Hours to 1.0 Volts at Indicated Variable Combination Levels			
	High-High	High-Low	Low-High	Low-Low	High-High	High-Low	Low-High	Low-Low
T X DOD	287	2112	1278	5662	560	1949	3002	6357
T X DR	773	1626	2593	4347	446	2063	2407	6952
T X CR	1698	701	3424	3516	1175	1335	2427	6392
T X CHG	1043	1356	3175	3765	1275	1234	4883	4477
T X PKOH	1176	1223	2946	3994	1300	1210	4110	5249
T X AKOH	1081	1318	3437	3503	1058	1452	4619	4740
T X PC	1200	1199	3441	3499	1352	1157	4679	4681
DOD X DR	374	1191	2992	4782	493	3070	2361	5946
DOD X CR	837	728	4286	3488	1049	2513	2553	5753
DOD X CHG	708	857	3510	4264	1902	1660	4255	4051
DOD X PKOH	678	887	3444	4330	1624	1938	3786	4521
DOD X AKOH	734	831	3784	3990	1750	1813	3927	4380
DOD X PC	803	761	3837	3937	1785	1778	4246	4060
DR X CR	2265	1101	2858	3115	1112	1741	2490	6525
DR X CHG	1634	1732	2584	3389	1625	1228	4533	4483
DR X PKOH	1377	1989	2745	3228	1148	1706	4262	4754
DR X AKOH	1856	1510	2662	3311	1569	1284	4108	4908
DR X PC	1841	1525	2800	3173	1638	1216	4393	4622
CR X CHG	2282	2841	1936	2280	1747	1856	4411	3856
CR X PKOH	2193	2930	1930	2286	1535	2067	3875	4392
CR X AKOH	2480	2643	2038	2178	1690	1913	3987	4279
CR X PC	2537	2585	2103	2113	1711	1892	4320	3946
CHG X PKOH	1979	2239	2144	2977	2976	3182	2434	3277
CHG X AKOH	2069	2149	2450	2672	2965	3193	2712	2999
CHG X PC	2276	1941	2365	2757	3472	2686	2559	3152
PKOH X AKOH	1983	2140	2536	2681	2473	2936	3204	3256
PKOH X PC	1982	2140	2658	2558	2644	2766	3387	3072
AKOH X PC	2342	2176	2299	2522	3031	2646	3000	3192

3. Multiple-Linear Regression

Multiple-linear regression is a statistical procedure which determines the coefficients or parameters of the equation

$$Y = b_0+b_1X_1+b_2X_2+\ldots+b_iX_i+\ldots+b_nX_n$$

such that the sum of squares of the difference of the values predicted by the equation and the observed values is a minimum. In the above equation the X's are the test parameters or products of the test parameters. The b_i's are the coefficients. Y is the cycle life. Therefore, using the data from the composite design matrix, the task was to find an equation which could predict the life of a cell when the independent variables were known.

This technique was used to fit the "best" composite set of significant factors, that were obtained from the analysis of variance, to the four failure definitions: Cycles to 0.0 Volts, Hours to 0.0 Volts, Cycles to 1.0 Volts, and Hours to 1.0 Volts. The composite set is the list in Table VI-1 with the addition of the squares of the significant main effect variables.

The stepwise regression procedure starts with the equation with the one variable that by itself does the best job of fitting the observed data. This variable may be one of many offered for selection. If little is known about the effects of the independent variables, many new variables may be formed from the original independent variables to help build a good model. To cover the possibility of a quadratic effect of a variable a new variable which is the square of an original variable can be formed. A variable which is the cross product of two independent variables is used when there is interaction between two variables. The process of creating new variables can be continued by using higher powers and higher order cross products. However, for simplicity, one hopes that these higher order effects are not significant.

The second step in the stepwise procedure is to find which of the remaining variables will give the best fit when added to the first variable entered into the model. This process is then continued to add terms to the model in the amount they contribute to producing a good fit. Also, at each step, each variable in the model is examined to see if its contribution is still significant. It is possible, at a later stage, that because of the combination of variables now in the model, a variable's contribution is no longer significant.

Four runs were made using these four definitions as dependent variables and four more were made using the natural logarithm of each of the responses. These eight runs were made using all available data which included factorial points, star points, and center point. No data was included for Packs 51N and 66N. No data was available for cycles to 1.0 Volt and Hours to 1.0 Volt for Pack 5N. In all cases the regressions were run using the pack averages as explained in the analysis of variance section. Since all terms of the "best" composite set were significant, the regression program was set to force all terms into the equation.

The regression equations obtained from the Accelerated Test Data are summarized in Table VI-7. For each of the eight choices of dependent variables, the coefficients of the independent variables are listed. Any independent variable which is not listed has coefficient 0. The choice of the variables included in the regression equations was done using stepwise linear regression.

The standard error of estimate in Table VI-7 is a measure of the goodness of fit of the regression equation.

$$\text{The Standard Error of Estimate} = \sqrt{\frac{\text{Mean Square Remainder}}{\text{Sample Size}}}$$

and is the standard deviation which should be used when estimating cycle life from the means of all indpedent variables.

A summary of the regression runs is presented in Table VI-8 which shows the order the variables entered, the sum of squares error and the R-squared value at each step. All variables were forced into the regression runs, but the summary data indicates that the last terms to enter do not add very much to the goodness of fit of the model. Therefore, the terms below the dashed line were dropped from the models. The decision as to what terms to drop was based on the decrease in the sum of squares error and the increase in the R^2 value. In all cases where design variable terms were questionable, the term was dropped. This resulted in the variable precharge being dropped in all cases and the variable percent of electrolyte being deleted in most cases. Since the amount of electrolyte was not in the models to start with, this leaves the prediction equations with only terms involving the five environmental factors.

The results of using the regression equations to predict, a packs's cycle life are listed in Table VI-9. Packs 1N through 82N, except packs 51N and 66N, were used to fit the regression equations. The average prediction error for these packs is approximately 1500 cycles or 1800 hours. Packs 83N through 86N are still cycling at normal test conditions and were not used to fit the regressions.

TABLE VI-7 REGRESSION EQUATIONS

Cycles to 0.0 Volts (dependent variable)		LN Cycles to 0.0 Volts (dependent variable)		Hours to 0.0 Volts (dependent variable)		LN Hours to 0.0 Volts (dependent variable)	
Coefficient	Independent Variable	Coefficient	Independent Variable	Coefficient	Independent Variable	Coefficient	Independent Variable
46231		11.861		37267		11.384	
+3.9095	T X DOD	-.0012354	T X DOD	+2.1901	T X DOD	-.0012454	T X DOD
+10.092	CR X DR	+.0083520	T X CR	-1849.2	CR	+.00014184	DOD X DOD
+.95968	DOD X CHG	-.0068466	CR X CR	+8.2832	DOD X CR	-.0011261	DOD X DR
-427.31	T	+.0027992	DOD X CR	+31.693	T X CR	-.0013791	CR X CHG
-801.33	DOD	-.40343	CR	-571.59	T	+.0041808	CR C DR
+3.3029	DOD X DOD	-.0024540	CHG	-372.49	DOD	+.0084732	T X CR
-63.496	CHG	-.00066425	T X T	+12.414	CR X CR	-.29566	CR
-7.1917	CR X CR	+.0062479	CR X DR	-1.3800	DOD X DR	+.0028486	DOD X CR
-2.0320	DOD X DR	-.0011482	DOD X DR	+1.3801	DOD X DOD	-.00067310	T X T
+328.31	DR	+.048019	DR	+33.565	CHG	+.000030318	CHG X CHG
-2.6759	DR X DR	-.00016009	DR X CHG	-3.3486	CR X CHG	-.0047197	CR X CR
-.89241	DR X CHG			+5.8068	CR X DR	+.00049801	DR X DR
+6.5822	T X CR						
-229.67	CR						
Standard Error of Estimate	1242 cycles	Standard Error of Estimate	.57	Standard Error of Estimate	1830 Hours	Standard Error of Estimate	.54

Cycles to 1.0 Volts (dependent variable)		LN Cycles to 1.0 Volts (dependent variable)		Hours to 1.0 Volts (dependent variable)		LN Hours to 1.0 Volts (dependent variable)	
Coefficient	Independent Variable	Coefficient	Independent Variable	Coefficient	Independent Variable	Coefficient	Independent Variable
36647		25.427		48942		30.131	
+3.4872	T X DOD	-.00068577	T X DOD	+2.6255	T X DOD	-.0033036	T X DR
+207.17	CR	-.00079067	DR X DR	+4.88515	T X DR	-.00066486	T X DOD
+.70822	DR X CHG	+.0089422	CR X DR	-1397.3	CR	-.74054	PKOH
-2.8024	DOD X CR	-.10584	DR	+16.796	CR X DR	+.011713	PKOH X PKOH
-5.9905	CR X CR	-.0078277	CR X CR	-815.96	DR	+.0026457	CHG
+2.7774	T X PKOH	+.96413	CR	-979.41	T	-.0031951	CR X CR
-671.57	DOD	-.54908	PKOH	+17.640	T X CR	+.0065002	CR X DR
+3.8916	DOD X DOD	+.0096604	PKOH X PKOH	-389.97	DOD	+.0060944	T X CR
-396.04	T	-.0016869	T X PKOH	+6.3180	DR X DR	-.29609	CR
+8.7168	CR X DR	+.0022208	T X T	+1.9308	DOD X DOD	+.00068890	DOD X DOD
-2.4619	PKOH X PKOH	-.16192	T	+15.183	CR X CR	-.087471	DOD
-305.68	DR	-.11660	DOD	+6.1039	T X T	-.28302	T
-.064016	CHG X CHG	+.00079050	DOD X DOD	+.89282	DR X CHG	+.0031593	T X T
+2.0743	DR X DR			-.031025	CHG X CHG		
Standard Error of Estimate	1128 cycles	Standard Error of Estimate	.71	Standard Error of Estimate	1394 Hours	Standard Error of Estimate	.622

Note: Regression Equation Model is $Y = b_0+b_1X_1+b_2X_2+\ldots+b_nX_n$ where b_i are the coefficients and X_i are the independent variable and Y is the dependent variable.

TABLE VI-8 REGRESSION SUMMARY TABLE

Cycles to 0.0 Volts			LN Cycles to 0.0 Volts		
Variable	Sum of Squares Error	R^2	Variable	Sum of Squares Error	R^2
T X DOD	413,550,122	.5319	T X DOD	60	.5857
CR X DR	367,156,223	.5844	T X CR	49	.6566
DOD X CHG	344,845,162	.6069	CR X CR	45	.6841
T	330,710,671	.6256	DOD C CR	39	.7273
DOD	248,598,901	.7186	CR	37	.7444
DOD X DOD	189,195,592	.7858	CHG	35	.7575
CHG	151,811,648	.8281	T X T	33	.7682
CR C CR	147,752,572	.8328	CR X DR	32	.7753
DOD X DR	137,631,508	.8442	DOD X DR	26	.8170
DR	134,986,399	.8472	DR	26	.8185
DR X DR	132,236,556	.8503	DR X CHG	26	.8195
DR X CHG	128,910,475	.8541	PC X PC	26	.8198
T X CR	125,965,395	.8574	CHG X PC	21	.8504
CR	123,484,413	.8602	PC	21	.8510
T X T	123,298,659	.8604	DOD X DOD	21	.8513
DOD C CR	123,122,629	.8606	DOD	21	.8539
CHG X PC	123,115,153	.8606	DOD X CHG	21	.8548
PC	123,114,719	.8606	T	21	.8552
PC X PC	123,113,363	.8606	DR X DR	21	.8552

Hours to 0.0 Volts			LN Hours to 0.0 Volts		
Variable	Sum of Squares Error	R^2	Variable	Sum of Squares Error	R^2
T X DOD	758,847,853	.3243	T X DOD	52	.4858
CR	583,490,247	.4804	DOD X DOD	48	.5214
DOD X CR	523,648,646	.5337	DOD X DR	45	.5603
T X CR	492,375,221	.5516	CR X CHG	42	.5881
T	397,396,189	.6461	CR X DR	38	.6208
DOD	332,336,242	.7041	T X CR	37	.6341
CR X CR	317,746,130	.7171	CR	31	.6899
DOD X DR	304,367,431	.7290	DOD X CR	27	.7349
DOD X DOD	292,031,669	.7399	T X T	25	.7490
CHG	286,529,723	.7448	CHG X CHG	24	.7598
CR X CHG	272,523,466	.7573	CR X CR	23	.7709
CR X DR	267,965,949	.7614	DR X DR	23	.7745
PKOH X PKOH	265,060,042	.7640	PKOH	23	.7749
PKOH	262,095,934	.7666	PC X PC	23	.7753
T X T	260,087,601	.7684	CHG X PC	18	.8169
DR X DR	259,142,071	.7692	PKOH X PKOH	18	.8175
DR	257,640,752	.7706	DOD	18	.8176
PC	257,383,781	.7708	PC	18	.8177
PC X PC	255,043,545	.7729	T	18	.8177
CHG X PC	254,867,257	.7730	DR	18	.8177

TABLE VI-8 (Continued)

Cycles to 1.0 Volts			LN Cycles to 1.0 Volts		
Variable	Sum of Squares Error	R^2	Variable	Sum of Squares Error	R^2
T X DOD	295,260,584	.4574	T X DOD	108	.5007
CR	283,309,709	.4793	DR X DR	77	.6470
DR X CHG	272,093,151	.4999	CR X DR	58	.7345
DOD X CR	259,835,201	.5224	DR	54	.7504
CR X CR	250,081,376	.5404	CR X CR	50	.7706
T X PKOH	242,279,727	.5547	CR	48	.7792
DOD	227,018,663	.5828	PKOH	46	.7867
DOD X DOD	158,283,898	.7091	PKOH X PKOH	45	.7906
T	119,336,635	.7807	T X PKOH	45	.7915
CR X DR	112,939,716	.7924	T X T	44	.7962
PKOH X PKOH	111,079,565	.7958	T	43	.7996
DR	110,302,991	.7973	DOD	43	.8026
CHG X CHG	105,034,013	.8070	DOD X DOD	40	.8167
DR X DR	101,864,144	.8128	CHG X CHG	39	.8180
T X T	101,100,742	.8142	DOD X CR	39	.8185
DR X PC	100,582,374	.8151	DR X PC	39	.8188
PC X PC	93,895,474	.8274	PC	39	.8193
PKOH	93,876,756	.8275	PC X PC	39	.8224
PC	93,876,037	.8275	DR X CHG	38	.8225

Hours to 1.0 Volts			LN Hours to 1.0 Volts		
Variable	Sum of Squares Error	R^2	Variable	Sum of Squares Error	R^2
T X DOD	476,008,439	.2480	T X DR	91	.4779
T X DR	382,346,900	.3960	T X DOD	54	.6898
CR	340,647,221	.4619	PKOH	52	.7017
CR X DR	327,034,311	.4834	PKOH X PKOH	50	.7139
DR	312,713,264	.5060	CHG	49	.7202
T	282,195,449	.5542	CR X CR	48	.7247
T X CR	244,022,894	.6145	CR X DR	43	.7569
DOD	214,718,055	.6608	T X CR	40	.7706
DR X DR	197,963,832	.6873	CR	37	.7861
DOD X DOD	179,045,715	.7172	DOD X DOD	36	.7946
CR X CR	168,125,812	.7344	DOD	34	.8059
T X T	159,879,865	.7474	T	33	.8093
DR X CHG	157,360,492	.7514	T X T	31	.8208
CHG X CHG	155,657,650	.7541	DR X DR	31	.8232
PC	154,088,680	.7566	DR	31	.8237
DR X PC	144,038,120	.7725	DR X PC	31	.8240
PC X PC	142,597,737	.7747	PC	31	.8246
PKOH	141,954,587	.7758	PC X PC	30	.8290
PKOH X PKOH	138,510,990	.7812	DR X CHG	30	.8293

TABLE VI-9 REGRESSION PREDICTIONS

Pack No.	Cycles To 0.0 Volts: Pack Average	Prediction Using Cycles	Prediction Using LN Cycles	Hours to 0.0 Volts: Pack Average	Prediction Using Hours	Prediction Using LN Hours
1N	10348	8476	10340	157[illegible]	11533	13682
2N	929	428	934	126[illegible]	1876	1443
3N	1634	2119	2108	1634	1067	1784
4N	3266	1957	1462	5552	4486	3020
5N	10642	6648	8424	21284	12944	19813
6N	716	903	761	1145	1479	992
7N	3007	2607	3076	2285	1464	2594
8N	3862	4749	2133	4712	3074	2086
9N	16773	10692	10641	6374	4460	4395
10N	17	-208	84	41	-1151	163
11N	2329	2330	2032	9316	7960	9434
12N	2046	2093	3094	1637	1729	2024
13N	8290	7900	7293	4145	4063	3023
14N	30	-696	57	103	260	236
15N	2971	1855	2494	9032	6548	6514
16N	5450	3921	3797	3706	2126	2944
17N	1320	428	934	1794	1876	1443
18N	8436	8476	10340	12822	11533	13682
19N	2505	1957	1462	4258	4486	3020
20N	10848	2119	2108	4122	4460	1784
21N	446	903	761	713	1479	992
22N	3050	6648	8424	6101	12944	19813
23N	4614	4749	2133	5629	3074	2086
24N	1937	2607	3076	1472	1143	2594
25N	32	-208	84	79	-1151	163
26N	10025	10692	10641	3809	4460	4395
27N	2664	2093	3094	2131	1729	2024
28N	2317	2331	2032	9266	7960	9434
29N	18	-696	57	61	260	236
30N	5600	7900	7293	2800	4063	3023
31N	4349	3921	3797	2957	2126	2944
32N	2894	1855	2494	8797	6548	6514
33N	2130	1200	727	7244	6286	3057
34N	3181	4061	6961	1591	1990	2905
35N	4676	7760	3979	3180	4199	3063
36N	1323	-41	197	4022	6548	503
37N	1289	1688	1060	3144	4875	2111
38N	6734	6853	10156	2559	2387	4224
39N	7106	5932	3242	5685	3802	2106
40N	584	434	161	2336	1934	728
41N	666	1614	2142	1065	1800	2769
42N	860	1624	1788	1719	5166	4143
43N	9460	9773	10050	11541	10852	9974

Pack No.	Cycles to 0.0 Volts: Pack Average	Prediction Using Cycles	Prediction Using LN Cycles	Hours to 0.0 Volts: Pack Average	Prediction Using Hours	Prediction Using LN Hours
44N	2454	1896	1093	1865	1143	920
45N	1408	1139	2629	1915	2197	4066
46N	3110	3452	2195	4728	3755	2861
47N	7537	6981	6888	12813	12264	14444
48N	796	1408	749	796	746	633
49N	3676	4061	6961	1838	1990	2905
50N	1690	1200	727	5746	6286	3057
51N	11	-41	197	36	522	503
52N	7492	7760	3979	5094	4199	3063
53N	6062	6853	10156	2304	2387	4224
54N	1637	1680	1060	3994	4875	2111
55N	432	434	161	1727	1934	728
56N	4926	5932	3242	3941	3802	2106
57N	2675	1624	1788	5350	5166	4143
58N	1670	1614	2142	2672	1800	2796
59N	1556	1896	1093	1183	1143	920
60N	8502	9773	10050	10372	10853	9974
61N	2349	3452	2195	3570	3755	2861
62N	2407	1139	2629	3273	2197	4066
63N	1030	1408	749	1030	746	633
64N	6353	6981	6888	10801	12264	14444
65N	4763	5830	8459	5430	8530	10171
66N	13	-300	386	15	-1471	454
67N	13864	13595	15087	5268	9183	11356
68N	685	2505	369	1301	2292	1097
69N	241	2312	1360	881	5287	2393
70N	1512	1667	1330	771	1529	793
71N	1582	1849	2484	3227	3961	3854
72N	1717	2094	1914	1571	1803	1787
73N	3241	3264	2689	3112	3125	2872
74N	1806	1768	1814	2710	4338	3178
75N	2522	2765	2358	2875	3530	2813
76N	1558	2765	2358	1776	3530	2813
77N	1909	2765	2358	2176	3530	2813
78N	2357	2765	2358	2687	3530	2813
79N	3574	2765	2358	4074	3530	2813
80N	2630	2765	2358	2998	3530	2813
81N	3041	2765	2358	3467	3530	2813
82N	3803	2765	2358	4335	3530	2813
83N	-	17029	50559	-	29424	55968
84N	-	20256	42024	-	22716	43942
85N	-	27073	72793	-	38123	76458
86N	-	11942	21978	-	15755	24198

TABLE VI-9 (Continued)

Pack No.	Cycles To 1.0 Volts: Pack Average	Prediction Using Cycles	Prediction Using LN Cycle	Hours to 1.0 Volts: Pack Average	Prediction Using Hours	Prediction Using LN Hours
1N	10088	6785	8112	15333	9882	13060
2N	189	991	248	257	1044	654
3N	1049	958	1342	1049	-262	1295
4N	199	615	273	338	736	256
5N	-	5219	6909	-	9570	11315
6N	714	11	381	1142	732	1036
7N	662	729	1143	503	-915	817
8N	375	972	420	458	83	295
9N	7374	6538	7291	2802	2266	2974
10N	12	-644	29	30	-997	48
11N	2089	1399	1493	8357	6390	5688
12N	2003	2495	2330	1602	1812	3509
13N	4228	5787	6210	2114	2919	2577
14N	21	-860	45	72	-345	75
15N	2049	1935	1272	6228	6701	3588
16N	4335	3616	3583	2948	2124	4050
17N	1320	1062	381	1794	1044	884
18N	7579	6270	6909	11520	9882	9654
19N	412	686	420	700	736	346
20N	9571	443	1143	3637	2266	2199
21N	442	-60	248	708	732	766
22N	2767	5734	8112	5534	9570	15306
23N	148	901	273	181	83	218
24N	1009	1244	1342	767	43	184
25N	25	-573	45	61	-997	64
26N	4600	6073	6210	1748	2266	2199
27N	2660	2565	3583	2128	1812	4747
28N	2272	884	1272	9088	6390	4205
29N	11	-930	29	37	-345	56
30N	5074	6302	7291	2537	2919	3486
31N	4345	3546	2330	2955	2124	2994
32N	2772	2450	1493	8427	6701	4853
33N	229	-478	200	777	1873	1003
34N	2606	2616	2400	1303	1775	988
35N	4674	6788	9270	3178	5025	3215
36N	1188	2450	1193	3610	6701	4853
37N	555	323	235	1354	1221	1158
38N	1959	2831	1561	744	1123	623
39N	5503	6252	10883	5202	4714	5097
40N	510	432	185	2039	2413	768
41N	663	393	1706	1060	1533	1400
42N	859	2043	2671	1718	3493	4759
43N	2122	4143	1087	2588	4401	2304

Pack No.	Cycles to 1.0 Volts: Pack Average	Prediction Using Cycles	Prediction Using LN Cycle	Hours to 1.0 Volts: Pack Average	Prediction Using Hours	Prediction Using LN Hours
44N	466	348	255	354	43	184
45N	1406	1959	2003	1912	1845	1616
46N	3079	3028	1737	4180	3805	3002
47N	4516	4373	1276	7677	5054	3652
48N	136	-9	166	136	695	160
49N	2965	2545	1561	1483	1775	731
50N	242	37	235	823	1873	1357
51N	-	1482	185	-	2725	655
52N	7482	7303	10883	5088	5025	4349
53N	2850	2902	2400	1083	1123	843
54N	308	-192	200	752	1221	856
55N	402	502	284	1607	2413	1039
56N	4923	5737	9270	3938	4714	3768
57N	2651	1977	1737	5302	3493	3518
58N	1663	908	2003	2660	1533	1894
59N	94	277	166	71	43	136
60N	4870	4659	1276	5942	4401	3116
61N	2349	3099	2671	3571	3805	4061
62N	2405	1444	1706	3271	1845	1195
63N	92	61	255	92	695	216
64N	3571	3857	1087	6071	5054	2700
65N	3427	3289	7118	3907	7170	11835
66N	-	-851	340	-	406	632
67N	13863	10722	16215	5268	6566	8171
68N	179	4169	317	339	2305	663
69N	17	775	333	61	3039	767
70N	438	569	366	223	722	219
71N	1582	2327	1140	3227	4046	1787
72N	14	147	18	13	781	27
73N	439	1444	640	422	1257	714
74N	426	423	640	639	1356	906
75N	872	1354	1597	994	1346	2213
76N	779	769	884	888	1346	1209
77N	797	1219	640	909	1346	773
78N	812	1219	640	925	1346	773
79N	3471	1219	640	3957	1346	773
80N	610	1219	640	695	1346	773
81N	475	1219	640	542	1346	773
82N	1706	1219	640	1945	1346	773
83N	-	11666	1597240	-	29424	6512420
84N	-	16226	163816	-	22716	212064
85N	-	20863	7116880	-	38123	22721600
86N	-	8423	27945	-	15755	46050

4. Non-Linear Regression

In analyzing the data, it was observed that the effect of some parameters can be better described using non-linear relationships with cycle life. As an illustration of this observation, the natural logarithm of cycles to 0.0 volts is plotted as a function of DOD (Figure VI-4) and as a function of temperature (Figure VI-5). The data points for each of the graphs are taken from Table VI-4 and Table VI-6. Table VI-6 is used to obtain an average ln (cycles to 0.0 volts) for packs cycling at the factorial levels of the test parameters. Table VI-4 is used for the packs cycling at the star point and center point levels of the test parameters. From the graphs it is seen that ln (cycles to 0.0 volts) is an approximately linear function of DOD and that ln (cycles to 0.0 volts) is approximately linear in temperature in the 20° C - 45° C range. The sharp drop in cycle life at 60° C is due, in part, to the charge inefficiency at high temperature levels. If the ln (cycles to 0.0 volts) is replotted as a function of DOD with varying temperature levels, a similar linear relationship (in slope) is observed across temperature levels. (Figure IV-6).

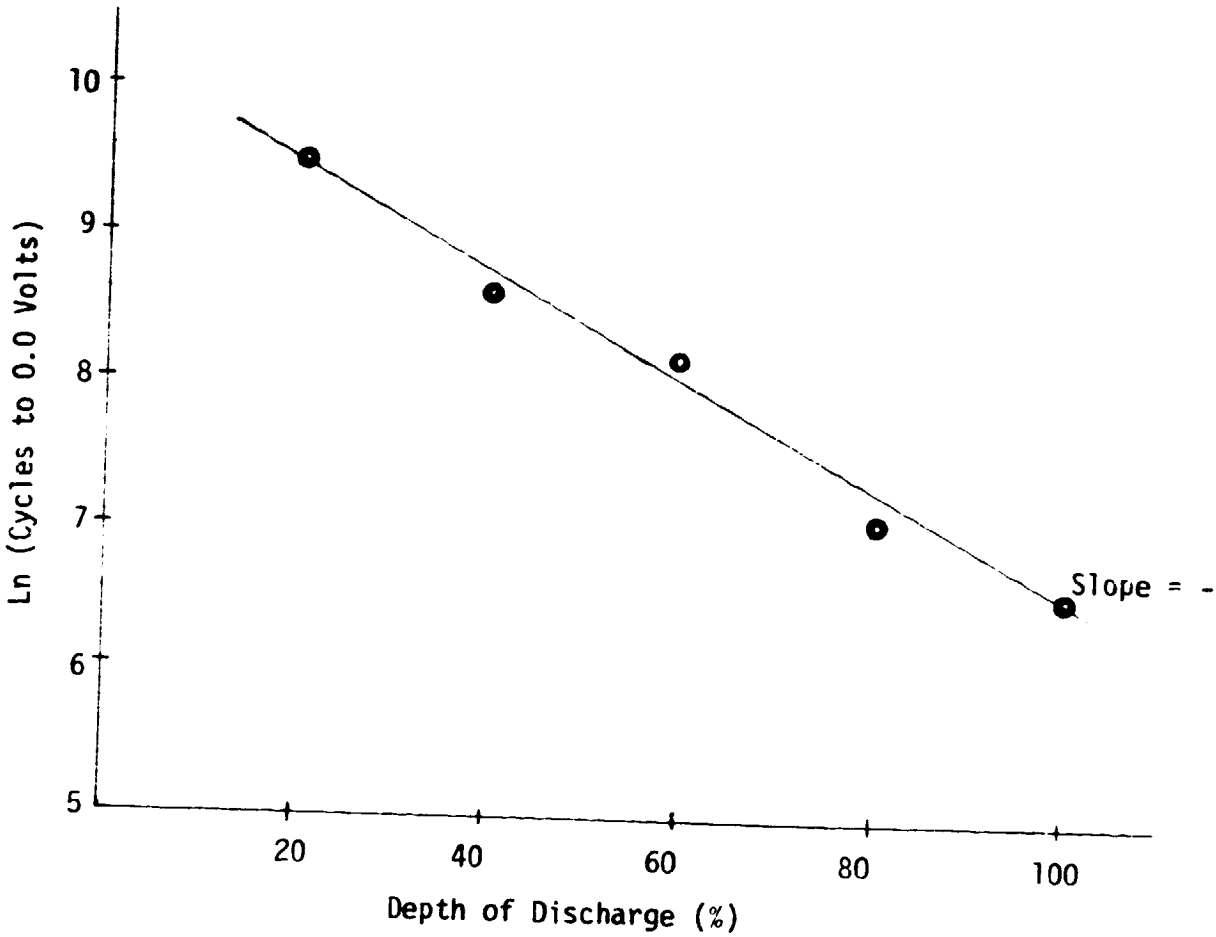


Figure VI-4 Ln (Cycles to 0.0 Volts) vs DOD. The average levels of the other parameters are Temp = 40° C, DR = 2C, CR = C, RECHG = 170%

Figure VI-5 Ln (Cycles to 0.0 Volts) vs Temperature

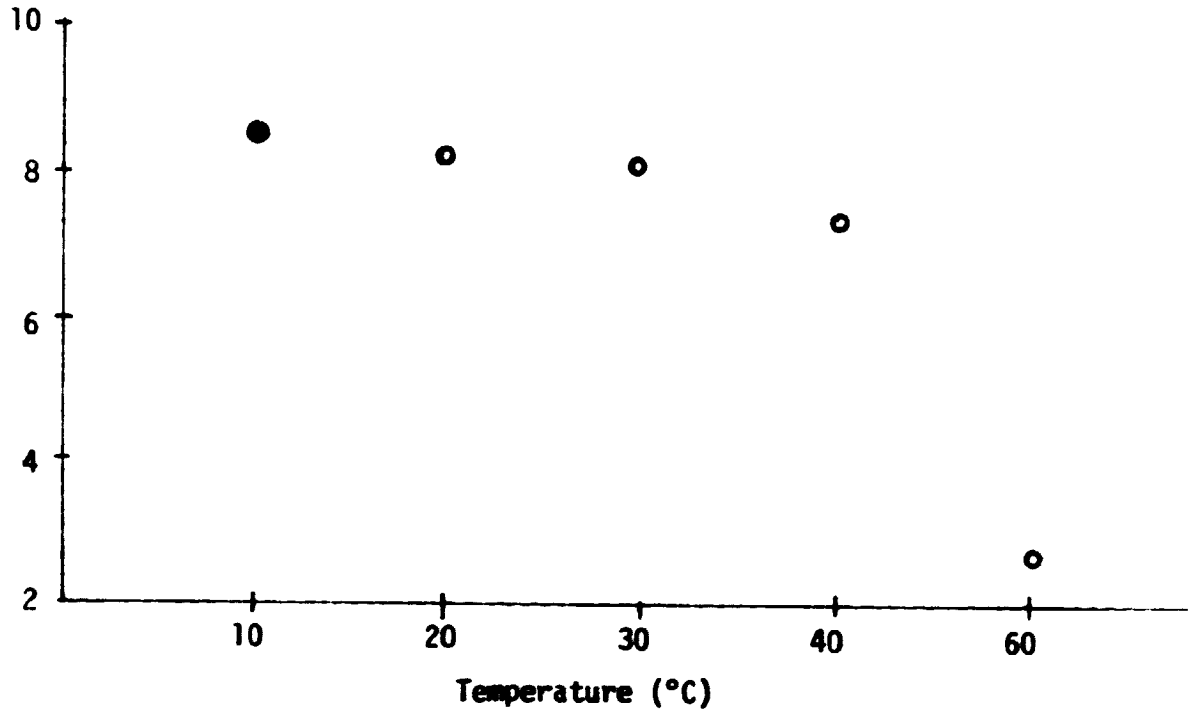
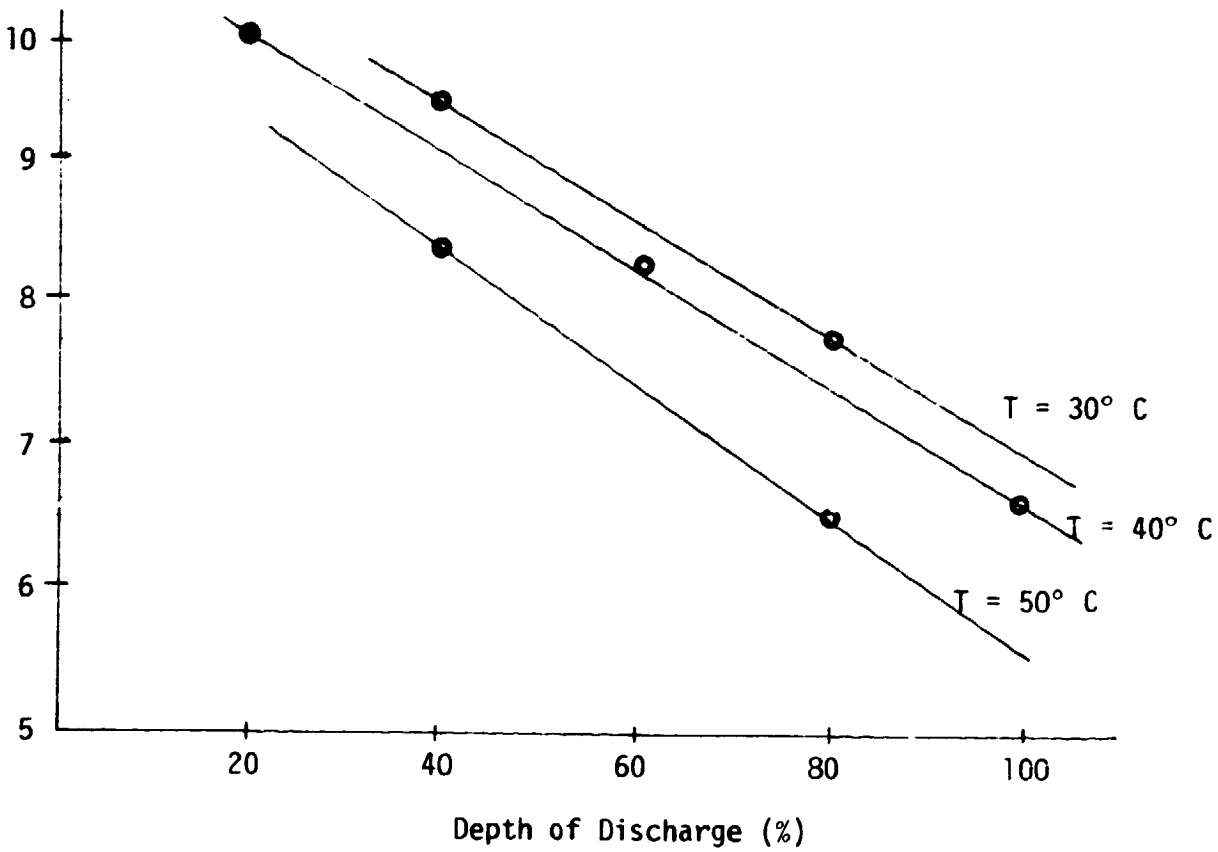


Figure VI-6 Ln (Cycles to 0.0 Volts) vs DOD and Temperature



Several equations that model battery cycle life were suggested by persons associated with the program. The equations were suggested prior to obtaining the analysis of variance results. Therefore, they are based on only three variables temperature, depth of discharge and percent recharge. In view of the results from the analysis of variance, it appears that the equation can provide a better model of cycle life when the effects of charge rate, discharge rate and percent of electrolyte are added. Refinement of these equations is a continuing process, as is investigation of new proposals. The equations tried are presented below. Additional work on the non-linear technique can be found in references 30 and 33.

$$\text{Cycle Life (to zero volts)} = a(b-\text{TEMP})\exp(c\text{DOD})$$

Coefficients Determined by Regression	Pack No.	Prediction of Normal Life
a = 1172	83N	17469
b = 66.8	84N	25910
c = -.0375	85N	36989
	86N	12239

(Run only with 140% recharge data)

$$\text{Cycle Life (to zero volt)} = \frac{a\left[\frac{123-\text{DOD}}{\text{DOD}}\right]^{b}\exp(c\text{TEMP})}{(\%\ \text{RECHARGE})^{d}}$$

Coefficients Determined by Regression	Pack No.	Prediction of Normal Life
$a = 7.3\times10^{6}$	83N	43813
b = 1.006	84N	49432
c = -0.0392	85N	108267
d = 1.257	86N	20004

$$\text{Cycle Life (to zero volts)} = a(bDOD+c(TEMP+273)^{-1})$$

Coefficients Determined by Regression	Pack No.	Prediction of Normal Life
	83N	31726
a = .1576	84N	26569
b = -.038	85N	67839
c = 3749	86N	12425

$$\text{Life (Hours) (to zero volts)} = \frac{a(1-\exp(b(TEMP-C)))\exp(dDOD)}{(\%Recharge)^e}$$

Coefficients Determined by Regression	Pack No.	Prediction of Normal Life (Hours)
	83N	16979
$a = 7\times10^6$	84N	15861
b = .0005	85N	22919
c = 64.236	86N	11750
d = -.015		
e = .4227		

5. TiBAR Technique

The TiBAR Technique was proposed from previous work performed at NAVWPNSUPPCEN Crane, reference 17, on cells under normal operating conditions. The technique is based on the theory that the rate of voltage drop on the discharge part of the life cycle is related to the goodness of the cell. It was shown that if the time to reach 1.25 volts is small, the cell is not usually as good as one that required a longer time to reach 1.25 volts.

It was anticipated that the mean of each pack could be predicted from the eight test parameters and that cell to cell variation within a pack could be explained by the average of the Ti values (TiBAR). This theory was applied to the composite design by using the eight test parameters and TiBAR values as independent variables in regression analysis of the general equation:

$$y = b_0+b_1X_1+b_2X_2 + \ldots +b_iX_i \ldots + b_nX_n$$

where y = cycle life to 0.0 volts
X_i = one of the independent variables
b_i = coefficient of the corresponding independent variable as determined by regression analysis of the data base.

The time to discharge (Ti) to a voltage of 1.25 volts had been an arbitrary choice, therefore, the levels of 1.26, 1.24, 1.23, 1.22, 1.21, and 1.20 were also used. It was also decided to try as a variable the time it took to go from one voltage level to another on the discharge curve (delta Ti). These times chosen were the time needed to go from 1.25 volts to 1.23 volts and from 1.24 volts to 1.22 volts. In addition, the time to reach 1.40 volts on the charge curve was used as a variable to evaluate the possibility that the charge curve might be an indicator of life.

The TiBAR technique was to screen the cells by cycling each cell for a few cycles and from the data determine a good cell. Thus a maximum of 300 cycles was arbitrarily chosen. Since it was possible that the very early cycles might behave differently, several sets of cycles were used. A total of 11 variables were created from the times. These were the means of Ti from 1 to 50, 51 to 100, 101 to 150, 151 to 200, 201 to 250, and 251 to 300 and the cumulative mean of each set of 50 cycles, 1 to 100, 1 to 150, 1 to 200, 1 to 250 and 1 to 300.

The regression analyses using the TiBAR values were performed early in the program. At that time, only 18 of the 82 packs had failed. The 18 packs were those that had been operated under the extreme most conditions of the test design. The results of these various regressions are presented in Table VI-10. The OBS FAIL TIME is the actual observed failure (to 0.0 volts) cycle for each cell. The remaining eleven columns contain the predicted failure cycle obtained from the regression analysis using the indicated data base as the independent variables. The independent variables used in the regression analysis of the 8 TEST PARA were: temperature (°C), depth of discharge (%), charge rate (ampere), discharge rage (amperes) percent recharged (%), concentration of electrolyte (%), amount of electrolyte (cc), and ampere-hours of precharge (ampere-hours). This creates a data base for the regression of 8 variables. In applying the TiBAR or delta TiBAR technique the data base was expanded to 19 variables by including the TiBAR of cycles as previously defined. From this data base, the computer regression program chooses the coefficients of the general equation that provide the "best" curve fit to the dependent variable, life to 0.0 volts. The predicted values are obtained by substituting into the equation the independent variables of the individual cell to calculate the life of that cell. When just the eight test parameters are used, the predicted life is for the pack rather than the cell; because all cells in a pack are tested with the same eight parameters.

The predicted values, using the eight test parameters, compared well with the average of the observed failure time of the packs, however, when the TiBARs were added, the predicted values did not order the individual cells within a pack the same as had been observed in actual testing. For example, in pack 65N cell 2 ran much longer than cells 4 or 5 but the predicted values were about the same. In pack 6N the order of observed failure was cell 1, 5, 4 and 3; the order predicted by the TiBAR was cell 5, 4, 3 and 1. The conclusion arrived at by this analysis was that the TiBAR is not sensitive enough to detect the small within pack variations. However, there are some facts that may have an impact on the TiBAR technique.

The data base consisted of only 18 packs of the total 82 in the design and these packs were tested under the extreme conditions. This heavily weighted the data at the extreme levels of the test design.

Hardware failures identified at that time were deleted from the analysis, but pressure failures were considered as true cycling failures. It has been determined in recent analysis that hardware and pressure failures should be included in the analysis as censored data.

More benefit to the program might be obtained from the TiBAR technique if the analysis was reviewed and rerun using a data base of the full test design and knowledge learned from the ANOVA and regression of eight test parameters.

TABLE VI-10 SUMMARY REGRESSION PREDICTIONS USING TiBAR TECHNIQUE

PACK NO.	CELL NO.	P*	OBS** FAIL TIME	8 TEST PARA	DISCHG 1.26	DISCHG 1.25	DISCHG 1.24	DISCHG 1.23	DISCHG 1.22	DISCHG 1.21	DISCHG 1.20	CHG 1.40	DISCHG 1.25 MINUS 1.23	DISCHG 1.24 MINUS 1.22
2N	1		960	917	882	795	1101	1049	1128	1053	1260	954	868	1001
	2		944	917	867	706	1093	1058	1203	1034	1143	947	905	1002
	3		836	917	733	836	1170	1095	1267	998	922	947	878	938
	4		943	917	989	563	1005	864	1066	952	877	955	986	1021
	5		941	917	839	862	1094	914	1076	907	821	965	969	1016
6N	1		601	696	496	976	856	767	728	702	598	539	509	744
	2		-	-	-	-	-	-	-	-	-	-	-	-
	3		810	696	478	670	645	572	482	648	830	530	519	768
	4		747	696	554	532	509	493	478	616	713	531	607	783
	5		704	696	589	694	442	422	495	591	465	533	699	813
17N	1	P	1085	1290	1603	1679	1268	1419	1175	1321	1213	1386	1264	1150
	2		1351	1290	1598	1564	1205	1384	1180	1330	1428	1385	1279	1148
	3		1333	1290	1576	1499	1370	1498	1275	1311	1324	1373	1230	1128
	4		1265	1290	1677	1311	1097	1240	1057	1225	1278	1377	1347	1161
	5		1329	1290	1580	1580	1249	1410	1186	1287	1285	1375	1274	1136
40N	1		-	-	-	-	-	-	-	-	-	-	-	-
	2		733	511	61	788	620	523	313	458	469	699	508	585
	3		541	511	533	472	708	604	457	565	551	400	597	525
	4		587	511	776	641	721	610	480	592	592	295	560	482
	5		438	511	555	462	715	602	456	564	552	314	596	542
42N	1		827	803	653	796	788	892	924	669	608	983	912	856
	2	P	518	803	1260	201	1017	1001	988	1426	1581	1237	527	716
	3		677	803	908	777	813	851	834	625	574	768	778	718
	4		953	803	892	1093	882	864	907	707	730	822	825	799
	5		961	803	967	1050	845	936	962	814	699	856	840	867
46N	1		3205	3162	2740	3388	3124	3216	3157	3234	3130	3339	3197	3235
	2		3015	3162	2601	3068	3158	3201	3090	3314	3200	3339	3144	3202
	3		2966	3162	3475	2749	2711	2617	2633	2565	2741	2687	2940	2759
	4		3174	3162	2949	3132	2959	3026	2933	3030	3016	3268	3133	3149
	5		3192	3162	3042	3029	3081	3060	2986	3158	3237	2701	3092	3082
55N	1	P	325	386	127	206	330	249	387	404	742	-83	501	315
	2	P	282	386	346	424	288	319	619	372	221	516	501	396
	3		433	386	406	416	298	325	602	397	401	530	351	218
	4		431	386	509	330	173	241	564	366	350	574	445	327
	5		429	386	273	235	202	215	446	301	16	494	753	705
65N	1		-	-	-	-	-	-	-	-	-	-	-	-
	2		5660	4763	4770	4757	4761	4788	4802	4820	4752	4759	4760	4736
	3		-	-	-	-	-	-	-	-	-	-	-	-
	4		4165	4763	4760	4801	4792	4835	4805	4802	4708	4764	4782	4815
	5		4465	4763	4760	4732	4737	4667	4683	4668	4830	4768	4748	4642
68N	1	P	523	701	585	603	619	755	631	647	631	723	610	826
	2	P	471	701	626	433	527	402	485	526	562	710	505	115
	3	P	523	701	633	476	565	563	544	559	587	700	543	402
	4		951	701	624	750	649	925	734	779	685	719	687	1125
	5		-	-	-	-	-	-	-	-		-	-	-

TABLE VI-10 (Continued)

PACK NO.	CELL NO.	P*	OBS** FAIL TIME	TEST PARA	DISCHG 1.26	DISCHG 1.25	DISCHG 1.24	DISCHG 1.23	DISCHG 1.22	DISCHG 1.21	DISCHG 1.20	CHG 1.40	DISCHG 1.25 MINUS 1.23	DISCHG 1.24 MINUS 1.22
69N	1		-	-	-	-	-	-	-	-	-	-	-	-
	2		183	130	415	267	215	146	23	26	132	99	141	38
	3		171	130	340	284	239	284	158	236	290	479	145	193
	4		127	130	337	315	248	316	186	266	308	-14	162	256
	5		130	130	337	317	248	312	176	252	292	136	163	255
70N	1	P	683	700	673	572	654	481	524	525	662	704	719	654
	2	P	758	700	654	773	682	579	706	748	695	705	768	752
	3	P	653	700	665	678	716	978	872	800	686	704	736	684
	4		-	-	-	-	-	-	-	-	-	-	-	-
	5		-	-	-	-	-	-	-	-	-	-	-	-
71N	1	P	1625	1394	1609	1450	1146	985	1224	1363	1338	1416	1548	1303
	2		-	-	-	-	-	-	-	-	-	-	-	-
	3	P	1185	1394	1582	1541	1846	2038	1782	1728	1584	1397	1143	1578
	4		-	-	-	-	-	-	-	-	-	-	-	-
	5		1414	1394	1033	1233	1232	1200	1219	1133	1302	1411	1533	1401
74N	1	P	1196	1517	1626	1388	1409	1497	1482	1327	1373	2126	1379	1196
	2	P	1195	1517	1621	1498	1492	1612	1463	1544	1579	2111	1415	1365
	3	P	1648	1517	1608	1497	1529	1554	1339	1578	1636	2112	1443	1398
	4		1803	1517	1600	1633	1558	1690	1432	1573	1559	2095	1564	1682
	5		-	-	-	-	-	-	-	-	-	-	-	-
75N	1	P	2447	2149	2171	2093	1833	1930	1929	2089	2250	2099	2093	1876
	2	P	1818	2149	2163	2152	1874	2121	2058	2232	2317	2107	2137	2093
	3	P	1490	2149	2181	2160	1863	2135	2121	2217	2289	2067	2115	2089
	4		2557	2149	2127	2327	1962	2302	2209	2477	2484	2117	2213	2388
	5		2486	2149	2152	2273	1923	2293	2256	2337	2325	2076	2189	2327
76N	1	P	1201	1337	2147	1950	1675	1404	1553	1845	1483	1399	1359	1715
	2	P	1667	1337	2090	1967	1693	1485	1513	2139	1849	1455	1417	1893
	3		1115	1337	2184	1815	1623	1112	1403	1513	1309	1461	1258	1364
	4		-	-	-	-	-	-	-	-	-	-	-	-
	5		-	-	-	-	-	-	-	-	-	-	-	-
78N	1	P	2237	2295	2336	2222	2324	2305	2324	2366	2395	2314	2408	2220
	2		2351	2295	2325	2347	2324	2323	2334	2315	2301	2327	2469	2334
	3		2339	2295	2326	2319	2327	2292	2286	2297	2316	2332	2459	2282
	4		2346	2295	2322	2397	2330	2378	2362	2341	2320	2324	2503	2442
	5		2360	2295	2325	2347	2328	2334	2328	2313	2303	2336	2480	2354
79N	1	P	2158	2547	2166	2129	2855	2515	2792	2542	2521	2324	2415	2492
	2		3310	2547	2171	2197	2848	2457	2732	2457	2469	2352	2431	2451
	3	P	1480	2547	2137	2336	2905	2675	2866	2585	2524	2330	2540	2860
	4		3679	2547	2162	2282	2876	2584	2838	2595	2553	2339	2484	2671
	5		-	-	-	-	-	-	-	-	-	-	-	-
80N	1	P	3223	2547	2190	2311	2346	2343	2389	2052	2141	2198	2513	2340
	2		2297	2547	2165	2424	2354	2398	2382	2196	2297	2157	2568	2438
	3	P	2328	2547	2203	2328	2355	2349	2427	2030	2124	2142	2503	2364
	4		2319	2547	2155	2384	2357	2420	2406	2182	2247	2144	2570	2469
	5		2467	2547	2149	2395	2365	2441	2429	2173	2199	2182	2584	2515

*Identifies pressure failure
**Observed fail time for the cell as determined at the time the regression was performed

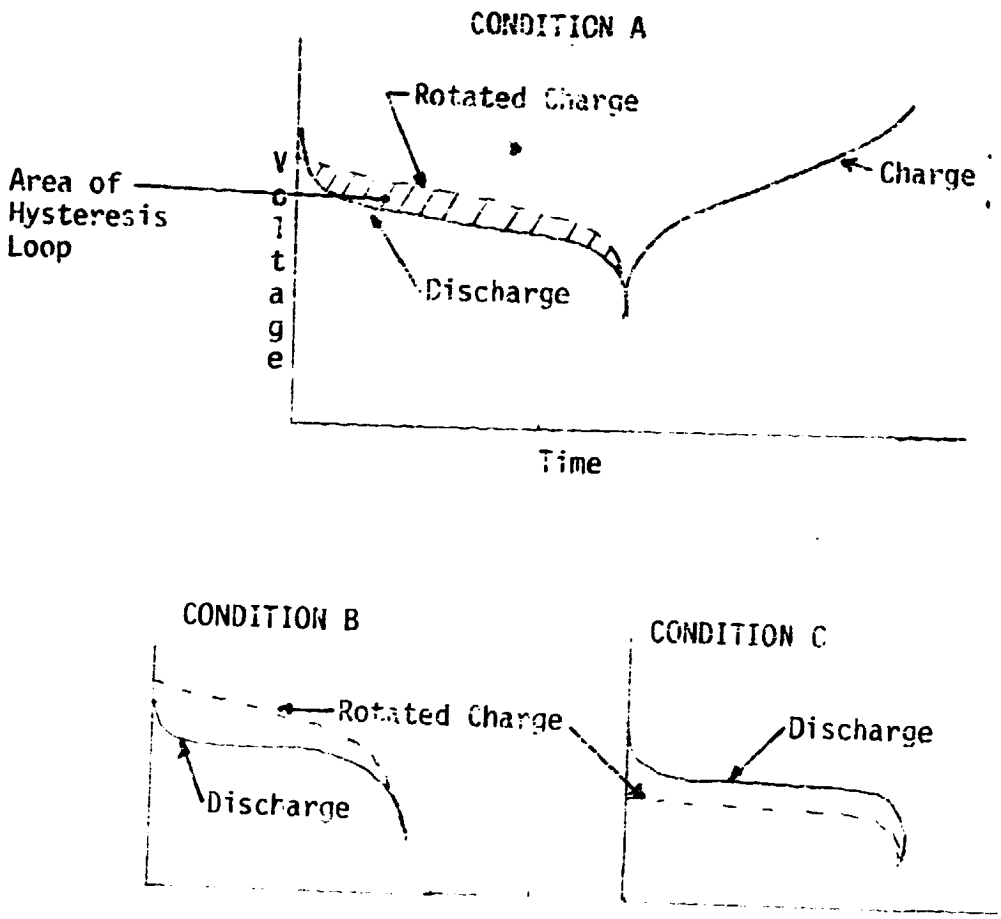
6. Hysteresis Loop Technique

In 1973 Cryptanlytic Computer Sciences, Inc. (CCS), while contracted to investigate nickel-cadmium battery test data for the behavior of cyclic discharge/charge cell voltage curves, defined a phenomena called "Hysteresis Loop". CCS demonstrated these phenomena (graphically) by superimposition of a segment of the charge curve over a segment of the discharge curve (within a given discharge/ charge cycle).

These phenomena appeared to measure, and be associated with, continuous changes in slope of the curves involved and to reflect the varying curve profiles induced by differing, real or simulated operational power requirements. These phenomena are apparent at the beginning of cell life and exhibit certain changes as a function of cycling time and may be correlatable to cell success and failure.

A computer program was written to accept the cell voltage data and numerically synthesize the discharge/charge curves on a per cell and per cycle basis. The computer program manipulated these curves so that the charge curve was rotated 180 degrees (which, in effect, reverses the direction of the plotted voltage levels) over the discharge curve in order to generate a "hysteresis loop".

FIGURE VI-7 EXAMPLES OF HYSTERESIS LOOP



A measure of this "hysteresis loop" is found by determining the difference in area between the charge and discharge curves. This procedure can result in one of three possible outcomes per cell and cycle as follows.

Condition A of Figure VI-7: The rotated charge curve intersects the discharge curve at some point, presenting an "area" bounded by (1) their mutual origin, (2) their intersection, (3) the discharge curve and (4) the charge curve. When this condition is detected, the computer program calculates a number representative of the enclosed "area" size and calculates the point in time of the intersection of the two curves.

Condition B of Figure VI-7: Where the rotated charge curve never intersects the discharge curve and is constantly positioned above it.

Condition C of Figure VI-7: Where the rotated charge curve never intersects the discharge curve and is constantly positioned below it.

When conditions B or C are encountered, the program computes the area enclosed within the curves, bounded by their common origin and the time period equivalent to the start-of-discharge.

The computer program provided a number for the area between the curves but no definite method of using the hysteresis loop for cell prediction was formulated by CCS. NAVWPNSUPPCEN personnel applied the hysteresis loop technique to the accelerated test data in the same manner in which the TiBAR was applied. The average value of the hysteresis loops for cycles 1 to 50, cycles 51 to 100, cycles 101 to 150, cycles 151 to 200, cycles 201 to 250, cycles 251 to 300, cycles 1 to 100, cycles 1 to 150, cycles 1 to 200, cycles 1 to 250, and cycles 1 to 300 were inputed with the eight test parameters as independent variables in the general regression equation:

$$y = b_0+b_1x_1+b_2x_2+\ldots+b_ix_i+\ldots+b_nx_n$$

Eighteen packs had failed at the time this analysis was performed. All cells were treated equally regardless of the failure mode and the packs used were from the extreme test conditions. As with the TiBAR regression, the purpose of the hysteresis loop variable is to separate and order the individual cells within a pack while the eight parameters give an average life of the whole pack.

Results of the regression run, shown in Table VI-11, indicate that this technique did not consistently predict the life of the cells nor did it order the individual cells the same as that seen in the observed cycling failure. For example, Pack 65N observed failures varied from 2564 to 5569 cycles but the predicted range was very narrow 3883 to 4035 cycles. If the hysteresis loop is to be a valuable predictor the correlation between the observed failure time and the predicted failure time should be consistently high. This correlation was run for each pack, but the results were inconclusive; varying from positive to negative and from low to high.

Visual evidence of the ineffectiveness of the hysteresis loop as a predictor can be seen in Figure VI-8. Although the value of the loop does change over the three hundred cycles, there is very little difference among the cells of the pack. The conclusion at that time was the cell to cell variation was not large enough to be accurately detected by this technique. As in the TiBAR, there are some facts that may have had an influence on the unsuccessful results of the technique.

The data base consisted of only 18 packs of the total 82 in the design and these packs were tested under the extreme conditions. This heavily weighted the data at the extreme levels of the test design.

Hardware and pressure failures were considered as true cycling failures. It has been determined in recent analysis that hardware and pressure failures should be included in the analysis as censored data.

The hysteresis loop technique was derived from data gathered on cells tested under more normal conditions. In developing this technique the difference in the length of time of the charge and discharge curve was small. In the accelerated test data this is not always true thus, using this variable may have created some problems. It is recommended that future efforts using this technique on accelerated test data should be performed on normalized charge and discharge curves or another variable, such as ampere-hours in and out, could be used.

TABLE VI-11 REGRESSION PREDICTIONS HYSTERESIS LOOP TECHNIQUE

CELL POS NO.	OBS* FAIL TIME	HYSTERESIS LOOP	CELL POS NO.	OBS FAIL TIME	HYSTERESIS LOOP	CELL POS NO.	OBS FAIL TIME	HYSTERESIS LOOP
PACK 6N			PACK 65N			PACK 75N		
1	601	599	1	2564	3968	1	2505	1834
2	485	473	2	5569	3989	2	1835	1794
3	811	694	3	2564	3883	3	1535	1828
4	747	681	4	4086	4035	4	2560	1730
5	704	471	5	4468	4029	5	2486	1977
PACK 36N			PACK 67N			PACK 76N		
1	1369	1508	1	8242	10100	1	1202	1828
2	1376	1452	2	9053	10090	2	1669	1909
3	1368	1264	3	9053	10110	3	1669	1876
4	1356	1121	4	14070	10100	4	1115	2000
5	1328	1059	5	13660	10110	5	1669	2044
PACK 40N			PACK 68N			PACK 77N		
1	398	-62	1	524	1911	1	1909	1322
2	690	-146	2	472	-194	2	1909	1143
3	546	-143	3	524	1419	3	1909	1273
4	583	196	4	955	1413	4	1909	1338
5	431	784	5	955	2400	5	1909	1353
PACK 42N			PACK 69N			PACK 78N		
1	831	1767	1	592	619	1	2232	2179
2	549	1985	2	592	750	2	2330	2436
3	680	1790	3	172	955	3	2319	2398
4	953	1562	4	148	-591	4	2319	2476
5	961	1707	5	148	-113	5	2339	2505
PACK 46N			PACK 72N			PACK 79N		
1	3205	3835	1	1351	1451	1	2321	3113
2	3174	3800	2	1717	1492	2	3260	3179
3	2973	3079	3	1352	1418	3	1481	3161
4	3174	3680	4	1717	1463	4	3628	3099
5	3182	3643	5	1717	1497	5	3680	3164
PACK 55N			PACK 74N			PACK 80N		
1	332	-643	1	1196	1581	1	3063	2410
2	303	-245	2	1196	1706	2	2268	2211
3	432	-398	3	1751	1787	3	2899	2142
4	431	-428	4	1808	2106	4	2268	2377
5	431	-470	5	1811	1972	5	2416	2386

*Observed failtime for the cell as determined at the time the regression was preformed.

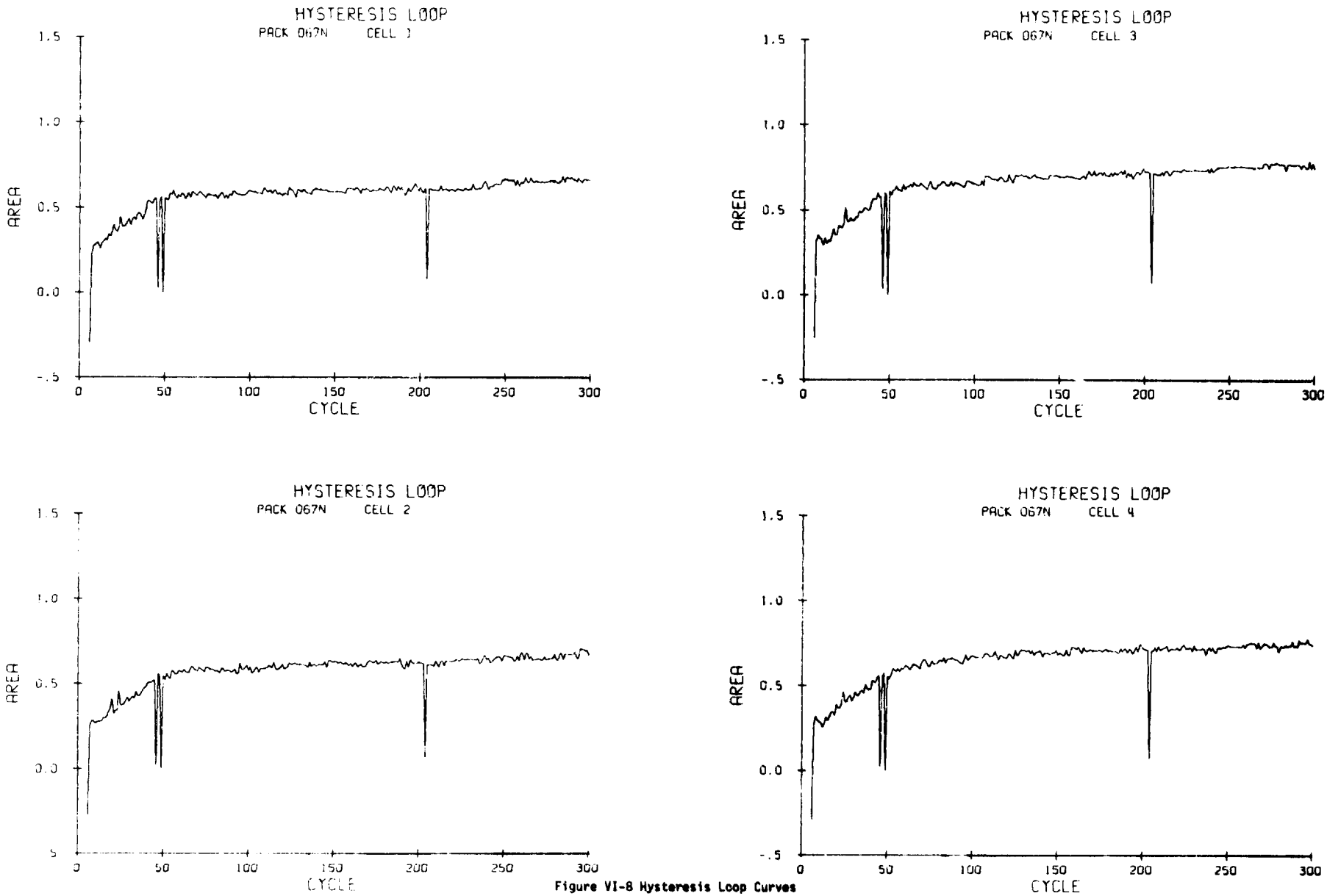


Figure VI-8 Hysteresis Loop Curves

7. Charge/Discharge Curve Fitting

Early in the program, an investigation was made of the possiblity of using the charge or discharge voltage curves to predict the cycle life of a cell cycling at accelerated test conditions. The proposed technique was to fit the discharge voltage curve (charge curve) to an equation of the form:

$$v = b_0+b_1t+b_2t^2+b_3t^3+b_4t^4$$

This curve fit could be repeated every n cycles, thereby obtaining several sets of coefficients. It was hoped that the coefficients would vary in such a way that the changing shape of the discharge curve could be predicted, thereby enabling the prediction of cycle life.

This technique was unsuccessful when applied to either the charge or discharge curve because of the seemingly random fluctuations of the coefficients b_i.

Another approach, in references (28) and (34), suggests that the voltage curves can be modeled by the use of two exponential functions, one for the beginning of the curve and a second for the end of the curve but with opposite slope. The model proposed for voltage as a function of time is:

$$v(t) = a+b \exp(-ct) -d \exp (f(t-t_m))$$

where the constants a, b, c, d and f are the parameters to be fitted and t_m is the time at which the discharge was ended. This technique was derived by reviewing a comparatively small amount of data that was available at the time. Before any conclusions can be made, a more detailed analysis is required.

B. CHEMICAL AND PHYSICAL DATA ANALYSIS

To date most of the effort has been expended in analysis of the cycle life data and prediction equations. Most of the effort expended on the chemical and physical data has been involved in assuring that data presented in the tables are correct. Little effort has been expended in analyzing the data. However certain trends were observed from the data tables. These trends are:

- The positive plate thickness incereases with cycle life.
- Cycled negative plates show a decrease in weight and capacity with cycling.
- The residual undischarged cadmium is greater in cycled cells than uncycled cells.
- The cycled positive plates contain more oxidized nickel than uncycled cells.
- There is a significant variation among the three plate lots used to fabricate the cells.
- The quantity of carbonate found in the cells increases with cycle life.

1. Variation In Plate Lots

During the physical and chemical analysis, it was observed that variations in the test data seemed to be related to the plate manufacturing lot. The test cells were built at different times using plates from three different lots, designated as lots 1, 2 and 4. Lot 1 cells comprised the star point, center point, storage conditions and normal point packs. Cells from lots 2 and 4 were received at a later date and made up the 64 packs of the factorial packs of the test matrix. To investigate the suspected variation, the uncycled cells of each lot were used. This was a total of 16 cells, 8 cells from lot 1, 4 cells from lot 2 and 4 cells from lot 4. The data for each of the variables measured was averaged for each plate position in cell and plotted as Figures VI-9 through VI-12. The figures show that some variation in the plate lots exist and the plates appear to have been ordered by weight as the curves of weight comparisons are very similar. The effect that these small variations in plate lots have on life cannot be determined from this data as the lots are confounded with design variables and the test matrix was not designed to evaluate this factor. The following comparisons were made.

Plate Weight Comparison - Negative Plates. The average weight of lot 1 plates is less than lots 2 and 4. The plates in lots 2 and 4 weigh about the same. The difference between lot 1 and lots 2 and 4

is approximately .28 grams. The average curves of lots 1 and 4 are very similar. The curve of lot 2 is of different shape. The widest range of values is found in the lot 2 plates.

Plate Weight Comparison - Positive Plates. The average weight of positive plates increases from lot 1 to lot 2 to lot 4. The average increase from lot 1 to lot 2 is .28 grams. The average increase from lot 2 to lot 4 is .33 grams. The average curve of all three lots is very similar. The widest range of values is found in lots 1 and 4. Lot 2 has a very narrow range of values.

Plate Thickness Comparison - Negative Plate. The curve of average thickness shows that lot 1 plates are thinner than lot 2 and lot 2 plates are thinner than lot 4. Lot 1 plates range from .810 mm to .842 mm, lot 2 plates range from .816 mm to .851 mm and lot 4 plates range from .844 mm to .870 mm. The widest variation is in lot 2 plates.

Plate Thickness Comparison - Positive Plate. The curve of average thickness increases from lot 1 to lot 4 to lot 2. Lot 1 plates range from .730 mm to .755 mm, lot 4 plates range from .739 mm to .779 mm and lot 2 plates range from .760 mm to .792 mm.

Plate Chemical Capacity - Negative Plates. The largest difference from lot 1 to lot 4 is approximately 5% for plate 9. The widest spread of values is in lot 2.

Plate Chemical Capacity - Positive Plates. The difference between lot 1 and lot 2 is approximately 8% and between lot 1 and lot 4 is approximately 13%. The greatest variance is in lot 1 cells.

Plate Electrochemical Capacity - Negative Plates. The widest range of values is in negative plates of lot 4. The curves are similar to chemical results but percent differences between lots is greater.

Plate Electrochemical Capacity - Positive Plates. The widest variance is in lot 1. The capacity increases from lot 1 to 2 to 4.

FIGURE VI-9 PLATE WEIGHT COMPARISON BY LOTS (PLATES FROM UNCYCLED CELLS)

	NEGATIVE PLATE NO. (Position in Cell)											POSITIVE PLATE NO. (Position in Cell)									
PLATE NO.	1	3	5	7	9	11	13	15	17	19	21	2	4	6	8	10	12	14	16	18	20
LOT 1 AVERAGE OF 8 CELLS																					
HIGH	8.59	8.57	8.47	8.58	8.65	8.72	8.51	8.63	8.68	8.58	8.59	7.05	7.12	7.20	7.02	7.21	7.09	7.03	7.13	6.89	7.07
AVE	8.42	8.45	8.39	8.52	8.47	8.53	8.44	8.50	8.54	8.50	8.40	6.95	6.96	7.05	6.83	7.03	6.94	6.84	6.99	6.79	6.89
LOW	8.25	8.26	8.30	8.35	8.36	8.35	8.31	8.37	8.37	8.40	8.09	6.68	6.74	6.84	6.63	6.90	6.72	6.68	6.82	6.71	6.66
LOT 2 - AVERAGE OF 4 CELLS																					
HIGH	9.09	8.89	9.07	8.97	8.92	9.15	8.88	8.86	9.01	9.00	8.74	7.33	7.30	7.42	7.27	7.38	7.23	7.14	7.34	7.18	7.17
AVE	8.85	8.56	8.71	8.79	8.86	8.90	8.72	8.57	8.77	8.73	8.52	7.16	7.20	7.31	7.21	7.37	7.19	7.12	7.28	7.12	7.11
LOW	8.61	8.32	8.48	8.39	8.79	8.70	8.60	8.31	8.51	8.29	8.32	7.03	7.07	7.19	7.15	7.35	7.13	7.09	7.24	7.02	7.03
LOT 4 - AVERAGE OF 4 CELLS																					
HIGH	8.71	8.91	8.72	8.87	8.77	8.89	8.94	8.76	8.8[illegible]	8.67	8.79	7.58	7.70	7.77	7.70	7.68	7.75	7.67	7.80	7.58	7.65
AVE	8.69	8.70	8.64	8.75	8.73	8.75	8.74	8.60	8.73	8.61	8.69	7.46	7.55	7.56	7.55	7.64	7.53	7.51	7.63	7.46	7.56
LOW	8.63	8.53	8.57	8.58	8.89	8.68	8.63	8.47	8.53	8.56	8.60	7.18	7.49	7.39	7.33	7.57	7.30	7.42	7.36	7.39	7.47

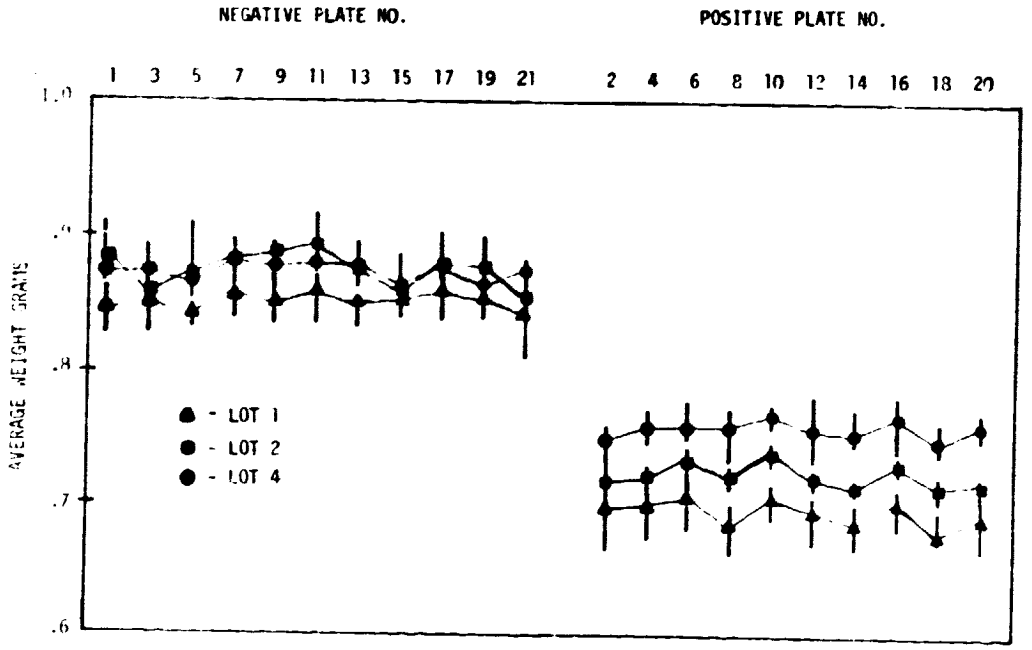


FIGURE VI-10 PLATE THICKNESS COMPARISONS BY LOTS (PLATES FROM UNCYCLED CELLS)

NEGATIVE PLATE NO. (Position in Cell)

PLATE NO.	1	3	5	7	9	11	13	15	17	19	21
LOT 1 AVERAGE OF 8 CELLS											
HIGH	.818	.842	.858	.866	.833	.875	.848	.898	.887	.852	.857
AVE	.810	.821	.833	.829	.817	.838	.827	.836	.842	.819	.815
LOW	.798	.805	.813	.797	.799	.811	.816	.804	.809	.738	.795
LOT 2 AVERAGE OF 4 CELLS											
HIGH	.877	.854	.848	.861	.857	.875	.856	.884	.850	.847	.831
AVE	.834	.834	.832	.844	.843	.851	.839	.844	.832	.830	.816
LOW	.809	.823	.820	.820	.828	.829	.826	.810	.821	.809	.800
LOT 4 AVERAGE OF 4 CELLS											
HIGH	.867	.871	.853	.906	.920	.861	.883	.853	.913	.916	.901
AVE	.850	.848	.844	.860	.870	.847	.854	.843	.864	.865	.845
LOW	.832	.818	.834	.834	.831	.837	.828	.820	.841	.837	.816

POSITIVE PLATE NO. (Position in Cell)

PLATE NO.	2	4	6	8	10	12	14	16	18	20
LOT 1 AVERAGE OF 8 CELLS										
HIGH	.785	.781	.766	.740	.761	.766	.770	.755	.755	.768
AVE	.742	.755	.739	.730	.741	.743	.735	.746	.734	.737
LOW	.711	.733	.715	.711	.719	.721	.709	.731	.715	.720
LOT 2 AVERAGE OF 4 CELLS										
HIGH	.796	.791	.795	.875	.792	.770	.787	.797	.798	.765
AVE	.769	.773	.772	.792	.773	.767	.771	.780	.769	.760
LOW	.754	.754	.761	.755	.757	.764	.760	.767	.754	.756
LOT 4 AVERAGE OF 4 CELLS										
HIGH	.770	.824	.771	.767	.755	.749	.750	.781	.777	.784
AVE	.747	.779	.752	.751	.744	.741	.739	.757	.742	.753
LOW	.718	.730	.729	.736	.735	.726	.728	.743	.728	.743

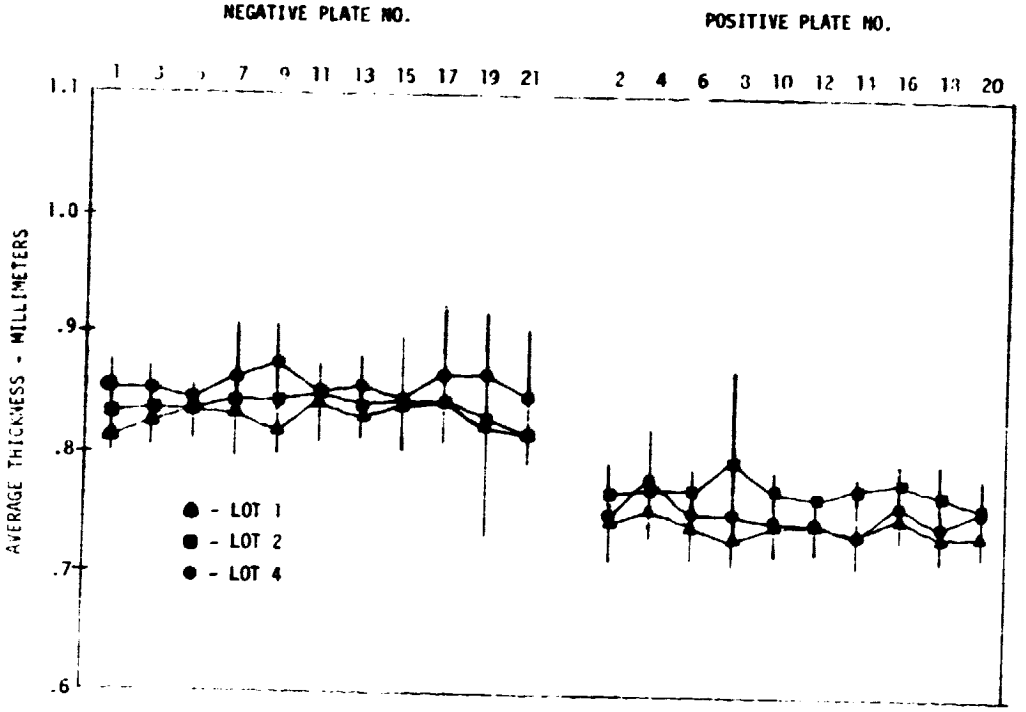


FIGURE VI-11 PLATE CHEMICAL CAPACITY BY LOTS (PLATES FROM UNCYCLED CELLS)

	NEGATIVE PLATE NO. (Position in Cell)			POSITIVE PLATE NO. (Position in Cell)		
PLATE NO.	3	9	13	2	8	12
LOT 1 AVERAGE OF 8 CELLS						
HIGH	1.700	1.716	1.740	.985	.971	.955
AVE	1.655	1.679	1.658	.925	.894	.892
LOW	1.622	1.637	1.585	.821	.795	.828
LOT 2 AVERAGE OF 4 CELLS						
HIGH	1.785	1.800	1.754	1.043	1.054	1.052
AVE	1.641	1.721	1.681	1.018	1.034	1.003
LOW	1.552	1.680	1.630	.978	1.004	.959
LOT 4 AVERAGE OF 4 CELLS						
HIGH	1.680	1.698	1.688	1.072	1.132	1.085
AVE	1.661	1.679	1.680	1.057	1.092	1.064
LOW	1.643	1.660	1.673	1.047	1.049	1.039

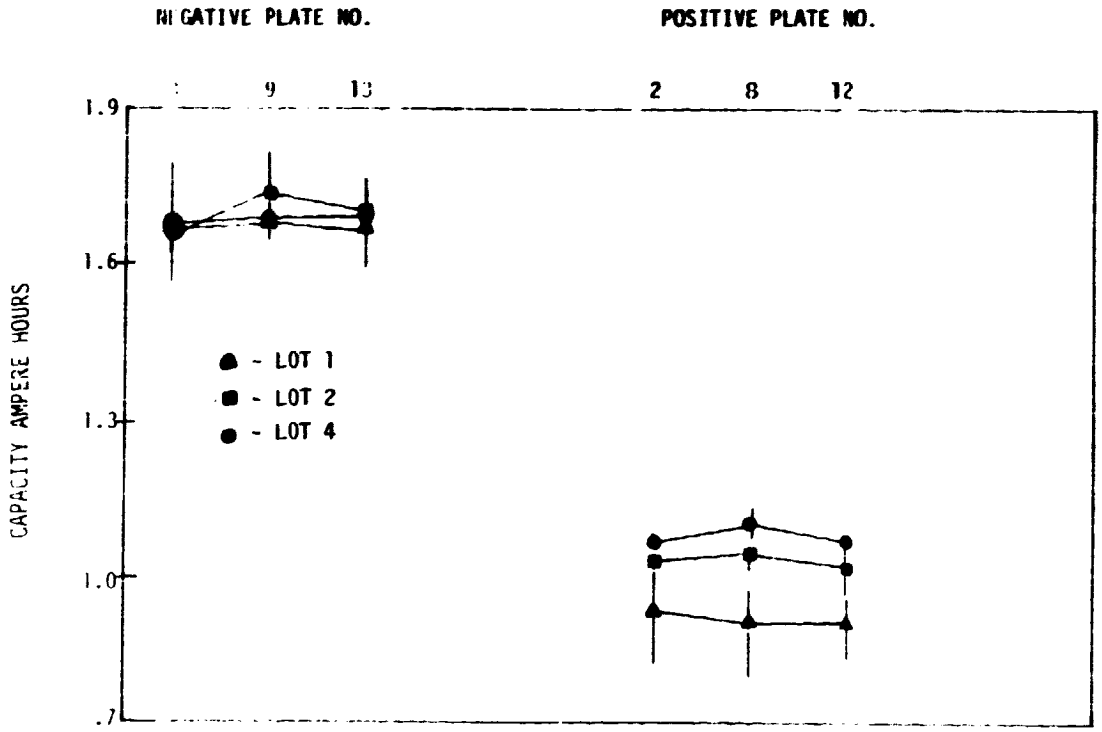
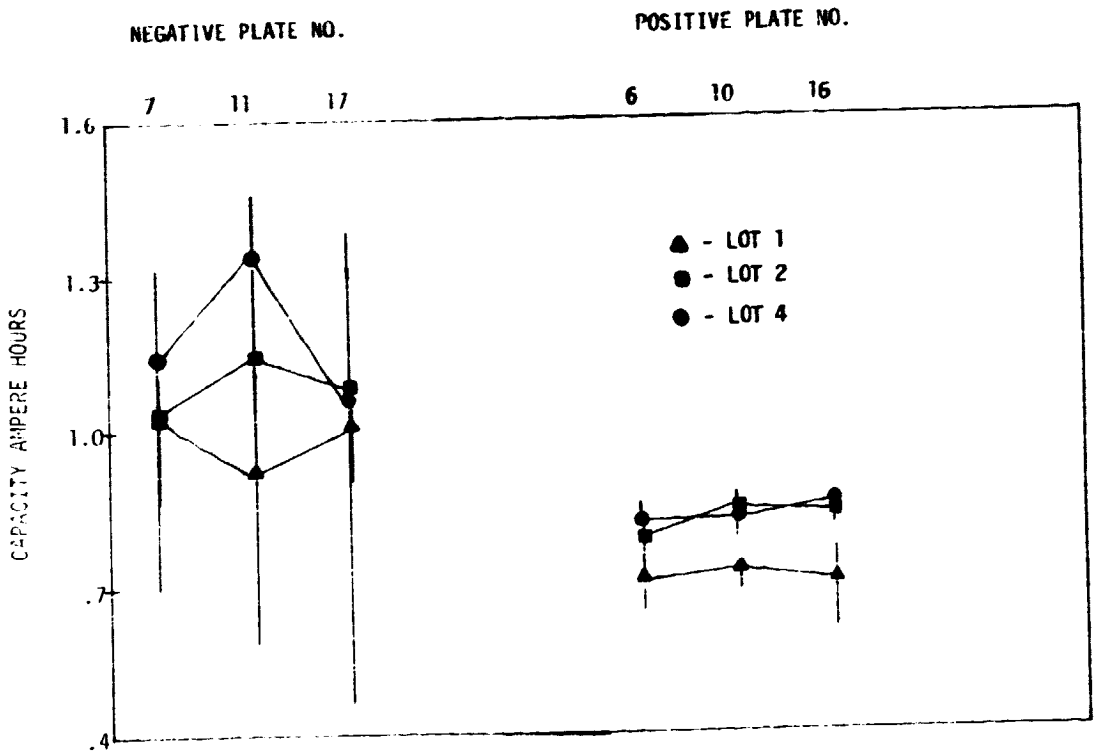


FIGURE VI-12 PLATE ELECTRO-CHEMICAL CAPACITY BY LOT (PLATES FROM UNCYCLED CELLS)

	NEGATIVE PLATE NO. (Position in Cell)			POSITIVE PLATE NO. (Position in Cell)		
PLATE NO.	7	11	17	6	10	16
LOT 1 AVERAGE OF 8 CELLS						
HIGH	1.10	1.10	1.07	.74	.74	.76
AVE	1.02	.90	.99	.69	.72	.69
LOW	.86	.59	.90	.64	.68	.60
LOT 2 AVERAGE OF 4 CELLS						
HIGH	1.32	1.45	1.33	.84	.84	.85
AVE	1.03	1.13	1.07	.78	.83	.83
LOW	.70	.89	.78	.72	.82	.81
LOT 4 AVERAGE OF 4 CELLS						
HIGH	1.34	1.40	1.38	.85	.88	.87
AVE	1.14	1.34	1.08	.82	.82	.85
LOW	.79	1.23	.47	.79	.79	.84



2. Plate Thickness Variation

A paired T-test was used to analyze any differences in thickness between the top and bottom of the cycled cells. Because of the variation in plate lots, cells from lot 1 were analyzed separately from the cells of lots 2 and 4. The results are shown in Table VI-12. It was concluded that any differences between the top and bottom thickness of the plates for cycled cells was similar to the differences found for uncycled cells.

TABLE VI-12

SUMMARY OF PAIRED T-TEST

TYPE CELL	TYPE PLATE	LOT NO.	NUMBER OF SAMPLES	AVERAGE DIFFERENCE (TOP-BOTTOM)	STANDARD DEVIATION	REMARKS
Uncycled	Positive	1	80	-.011963	.032175	Bottom size larger
Cycled	Positive	1	1460	-.012992	.053706	Bottom size larger
Uncycled	Positive	2,4	80	.009556	.045423	Not significant
Cycled	Positive	2,4	360	-.000260	.074516	Not significant
Uncycled	Negative	1	88	.014616	.032487	Top size larger
Cycled	Negative	1	1342	.014375	.042202	Top size larger
Uncycled	Negative	2,4	88	.016951	.002661	Top size larger
Cycled	Negative	2,4	418	.001735	.047287	Not significant

3. Cell Degradation and Failure Mechanisms

Dr. P. McDermott under contract to NASA/GODDARD has done the most extensive work in analyzing the chemical and physical data to determine what causes cell degradation (26)(29)(30). His analysis was performed on selected star and center point cell packs, and his findings are summarized below.

The increase of chemical capacity of the positive electrode with cycling could result from corrosion of the nickel sinter substrate. The oxygen utilized to oxidize the sintered nickel would not be available to recombine with the cadmium and the quantity of charged cadmium would increase with life. This, in effect, would cause the cell to lose overcharge protection and the cell could develop high pressures.

As the positive plate cycles it swells. This swelling can be attributed to two causes: 1) Expansion and contraction of the active material during cycling, 2) Corrosion of the substrate which weakens the structural integrity of the sinter. As the positive plate swells, there would be a corresponding decrease in the inner electrode spacing and the electrolyte is squeezed out of the separator. The drying out of the separator, which was verified in the analysis could contribute to both low voltage and high pressure failure by increasing the impedance of the cells and by restricting the diffusion of oxygen.

The electrolyte is squeezed from the separator and goes into the electrodes; the positives expand and the negatives have additional void volume due to loss of cadmium. The loss of cadmium from the electrode referred to as "cadmium migration" was verified in the tear-down analysis.

The failures which were attributed to internal shorting could be the result of the interaction of the mechanisms; plate growth, separator compression and cadmium migration into the separator.

Until it can be proven that the failure mechanisms are the same in the cells being tested under "normal" conditions as the cells tested at "stressed" conditions, the results of this test program are incomplete.

4. Chemical and Physical Data Bar Charts

A previous report (reference (2)) summarized the chemical and physical analysis performed and provided a graphical representation of the data in the form of bar graphs. These graphs were somewhat useful in studying trends of the cells with life. The charts comprise 200 pages and were too voluminous to include.

5. Positive Plate Growth

From the physical data it was found that the positive plate was expanding with cycling. This was initially investigated by Dr. P. McDermott and reported in references 26 and 29. This increase was determined to be due to the corrosion of the nickel sinter of the plate. Additional investigation using star point cells was performed by JPL.

It was found that the maximum cycle life of a given cell pack could usually be predicted based on a given increase in positive plate thickness. It was postulated that the positive plate thickness could increase to 0.975 cm maximum thickness and the cycle life was predicted based on this delta increase. Table VI-13 lists the maximum cycle life observed and predicted cycle life for the star point packs and one center point pack (No. 81). From the table it is seen that the predicted cycle life is very close to the observed cycle life in most cases.

Figure VI-13 shows regression plots of the positive plate growth as a function of cycle life. (It will be recalled that three cells were removed at various cycles before failure). Correlation coefficients of the plots in all but two cases were greater than 0.9.

TABLE VI-13 PREDICTED CYCLE LIFE BASED ON POSITIVE PLATE SWELLING

PACK NO	OBSERVED MAX C.L.	MAX. POS. THICKNESS CM	PREDICTED LIFE TO 0.0975 CM
65N	5660	0.0946	5400
66N	13	-----	-----
67N	14066	0.0842	38400
68N	955	0.1006	950
69N	591	0.0825	1600
70N	1512	0.0930	1800
71N	1638	0.0925	1900
72N	1717	0.1096	1300
73N	3501	0.0993	3500
74N	1801	0.0954	2150
75N	2557	0.0957	2400
76N	1669	0.0995	1750
77N	1909	0.1106	1450
78N	2368	0.0960	2400
79N	3732	0.1001	3732
80N	3223	0.0989	2600
81N	3055	0.0954	3200

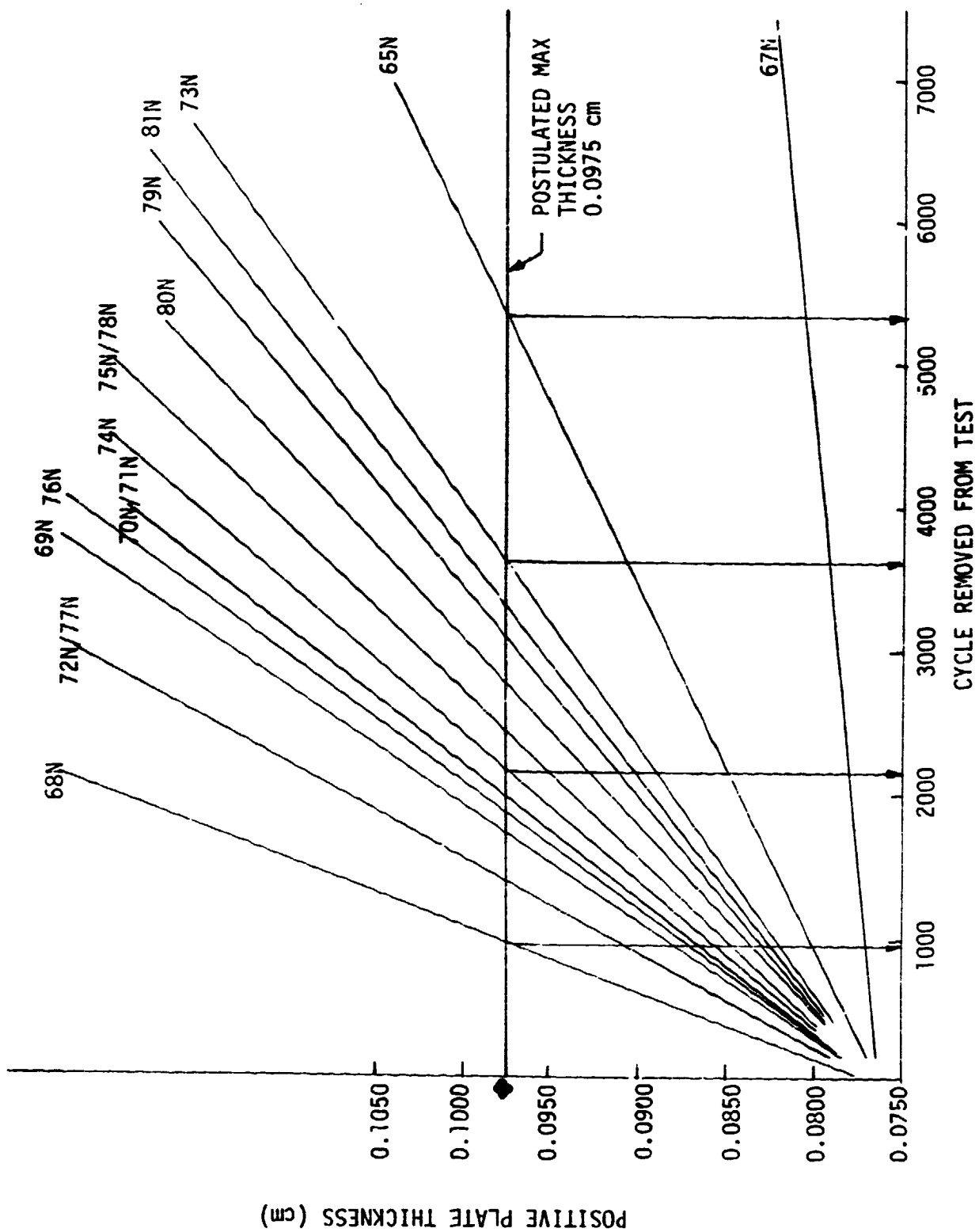


Figure VI-13 Positive Plate Growth as a Function of Cycle Life

Some observations that can be made from Figure VI-13 are:

a) The %DOD produces the greatest rate of positive plate growth (see 68N, 100% DOD VS 67N, 20% DOD).

b) Temperature appears to affect the positive plate swelling (Pack 65N at 20° C had next to the lowest swelling rate).

c) The swelling rate increases with the increase in KOH concentration (Pack 76N VS Pack 75N).

Other similar observations can be made on the effects of the test variables.

Although there is a very good correlation between positive plate growth and cycle life, caution must be exercised in assuming that positive plate swelling is the major failure mechanism. It is observed that Pack 67N, cycled at 20% DOD, had a maximum cycle life of 14,066 cycles but the maximum positive plate thickness was only 0.0842 cm. Its maximum cycle life was predicted to be 38,400 cycles based on reaching the maximum positive plate thickness of 0.0975 cm.

C. OTHER ANALYSIS

1. Histograms

The electrical data obtained from the manufacturer's tests, the baseline tests, and the chemical and physical tests were computerized and assembled into a data file totaling 72 variables. The purpose of the file was to assemble the data in the computer so that various correlations could be run. This data file was used to generate histograms of the data to investigate the distribution of the cells, to identify any inconsistancies that could be related to life, or help explain some of the premature failures. One set of histograms is presented in Appendix E.

One can select a given cell that failed early or out of line with the rest of the cells in a pack and pick that cell out in the histograms to determine where it is in relationship to its pack mates. Only a cursory review of the histograms has been made at this time. No specific trends were observed. Additional effort will be made to look at individual cell performances during life tests for comparison with the 72 data points in the histograms.

2. Analysis of Early Failures

The test parameters and levels were chosen so as to cause accelerated failure of the test cells. These parameters were fixed by the composite design resulting in combinations that would not sustain long term cycling. This problem occurred in the factorial points on pack 29N, 14N, 10N and 25N whose test parameters were 50° C temperature, 80% depth of discharge, C/2 charge rate and 4C discharge rate and in the star point, pack 66N in which the temperature was 60° C. When these packs were included in the regression prediction, the predicted life of the cell was a negative number.

In addition, a larger than expected number of the cells failed due to high pressure. Pressure failures are not normally encountered under normal conditions. Thus, the pressure failures were probably a result of the test parameters. The gas analysis results show that the high pressure was caused by hydrogen generation.

Reference (13) investigated early failures of the test program. This report concludes that the pressure failures resulted from being overcharged at the high charge rates of the test design.

3. Computerized Pattern Recognition

A computerized pattern recognition technique was used, in an independent study by Byers and Perone, to look for cell characteristics which would be predictive of later performance under stressful conditions (Reference 5). In this work the manufacturing test data was used to look for patterns that would differentiate between "good" and "bad" cells on the accelerated test.

In performing this analysis the authors were unable to identify cell performance characteristics from the manufacturers' test data that would accurately distinguish between good and bad cells on cycle life tests performed at NAVWPNSUPPCEN. Their analysis was performed on 220 cells that had completed the cycle tests at NAVWPNSUPPCEN. Correlations between the manufacturers' tests and the accelerated life times were complicated by the fact that the test program contained so many variables.

It was noted that there was a high degree of clustering of cells with respect to the cell design groups. It was also possible to distinguish cells manufactured from different plate lots. Charge voltage features and the time to discharge to 1.0 V were found to be better predictors than pressure features. Cell voltages were not found to be useful for predictions after the cells reached a 100% state of charge.

APPENDIX A

BASELINE TEST PROCEDURE

I. MEASUREMENTS Measure height, length, width, and weight.

II. CAPACITY TESTS 20 ±2° C.

A. Charge at 300 ma. for 40 hours or to 1.60 volts per cell limit. Set pressure cutoff at 100 psia.

B. Open circuit stand for one hour.

C. Discharge at 3.0 amperes to 0.75 volts, each cell. Open circuit each cell at the cutoff voltage.

D. Open circuit stand one hour after last cell discharges.

E. Charge at 600 ma. for 16 hours or to 1.60 volt per cell limit. Set pressure cutoff at 100 psia. Measure internal impedance within 5 minutes after end of charge.

F. Open circuit stand one hour.

G. Discharge at 3.0 amperes to 0.75 volts, each cell. Open circuit each cell at the cutoff voltage.

1. Measure internal impedance.

2. Record pressures decay during discharge at 15 minute intervals.

H. Short with a 0.5 resistor for 16 hours. During this period, record pressure decay, every two hours, if end of discharge pressure is greater than 15 psia.

III. CHARGE EFFICIENCY TEST 20 ±2° C.

A. Remove resistors and charge at 150 ma. for 20 hours.

B. Open circuit stand for one hour.

C. Discharge at 3.0 amperes to 0.75 volts, each cell. Open circuit each cell at cutoff voltage.

IV. INTERNAL SHORT TEST 20 ±2° C.

A. When the last cell reaches the cuttoff voltage of III C and the pack is removed from discharge, discharge with a 0.5 ±3% resistor across each cell for 16 hours. Measure the decay voltage of each cell every hour during the 16-hour period.

B. Remove resistor and measure recovery voltage every 30 minutes until cell voltage is equal to or greater than 1.15 volts. Then read once every hour for the remaining time. Total time of test to be 24 hours.

V. LEAK TEST

A. Leak test cells in a bell-jar vacuum system.

B. Phenophthalein leak check cells and weld closures.

VI. SHORT CELLS ON 0.5 OHM RESISTOR UNTIL INITIATION OF ACCELERATION TEST.

No voltage reading required. Time limit in storage to be three days.

VII. TEMPERATURE CONDITIONING, MATRIX TEMPERATURE

Condition cells at the matrix temperature for a minimum of 8 hours.

VIII. CAPACITY TEST, MATRIX TEMPERATURE

A. Remove resistors and charge cells at matrix temperature at 600 ma. for 16 hours or to 1.60 volt per cell limit. Measure internal impedance within 5 minutes after end of charge.

B. Open circuit stand for one hour.

C. Discharge at 3.0 amperes to 0.75 volts, each cell. Open circuit each cell at the cutoff voltage. Measure internal impedance within 5 minutes after last cell completes discharge.

D. Short with a 0.5-ohm resistor for 16 hours. During this period, record pressure decay every two hours, if end of discharge pressure is greater than 15 psia.

IX. CAPACITY TEST, MATRIX TEMPERATURE, MATRIX RATE

A. Remove resistor and charge cells at matrix temperature and matrix rate to matrix overcharge. Measure internal impedance within 5 minutes after charge is complete.

B. Open circuit stand for 10 minutes.

C. Discharge at matrix discharge rate to 0.50 volts, each cell. Open circuit each cell at cutoff voltage. Measure internal impedance within 5 minutes after last cell completes discharge.

D. Short with 0.5-ohm resistor for 16 hours. During this period, record pressure decay every two hours, if end of discharge pressure is greator than 15 psia.

5. INITIATE ACCELERATED TEST

A. Remove resistor and charge cells at matrix temperature, rate and overcharge.

B. Discharge cells at matrix depth of discharge and matrix rate. This cycle is to be designated cycle six (6) of the Accelerated Test for the pack.

APPENDIX B

TEST FACILITIES

A. ENVIRONMENTAL CHAMBERS

The ambient test temperatures of 0° C, +20° C, +30° C, +40° C, +50° C, and +60° C are maintained by environmental chambers with temperature controls accurate to within ± 1.5° C. Test items cycling at +25° C are located in an air conditioned room with other temperature-critical equipment, and the temperature is maintained at 25° C ± 2° C.

B. AUTOMATIC DATA ACQUISITION AND CONTROL SYSTEM (ADACS)

1. Summary:

a. The system is capable of testing 256 packs with 3000 channels available for data input from these packs.

(1) Each pack has its own power supply, or may use dual power supplies, with its corresponding system interface, remotely programmed by the system to provide its test requirements. During test, the system routinely scans each pack's data every 36 seconds and compares each data point (voltage, temperature, or pressure) with programmed limits to insure that the test items meet test specifications. If the parameter is out of limits the system will initiate an alarm and also type out a message identifying which pack's parameter was out of limits.

(2) As data is being scanned, it is recorded on magnetic tape and also on a teletype, in report form, if requested.

(3) The system was designed to provide an accuracy of 1.0 millivolt on directly read data such as auxiliary electrode and cell voltages. The accuracy of temperature (thermistor) and pressure (transducer) measurements are 0.05° C and 0.05 psia, respectively.

b. The system is organized into three functional hardware groupings as follows.

(1) Computer and computer peripherals:

(a) Honeywell 316 computer and options;

(b) Two ASR35 heavy duty teletypes;

(c) Honeywell 316-50 high speed paper tape reader and spooler;

(d) Datum, Inc., Model 5091-H316 magnetic tape I/O system with two tape transports;

(e) Datum, Inc., Model 6078-H316 mass memory system with 131,000 word drum memory;

(f) Tally, Model 2200 line printers;

(g) Texas Instruments Silent 700 Deck Printer.

(2) Auxiliary digital functions include:

(a) Real-time clock, system shut-down timer and alarm circuits, and medium-speed analog input subsystem;

(b) Two John Fluke, Model 8300-A digitizers;

(c) 3000-channel reed relay scanner.

(3) Control subsystem:

(a) 256 control channels providing the digital-to-resistance conversion and control-relay outputs to the interface between the system and the test items.

2. Measurements:

a. Cell voltages are presented directly to the system. Throughput measurement is 1.0 millivolt maximum.

b. Currents are measured by sampling the voltage drop across a low-resistance shunt of 100 MV full current value. Through output measurement, error of the shunt voltage is 1 millivolt maximum.

c. Cell and ambient temperatures are measured by sampling the output of a thermistor bridge driven by an excitation voltage. The temperature range is -30° C to +70° C and is resolved in increments of 0.1° C., with an error of less than 0, 05° C, resulting from linearity.

d. Cell pressures are measured by sampling the output of a pressure transducer driven by an excitation voltage. The pressure range is 0 to 300 psia, and is resolved in increments of 0.1 psia with an error of less than 0.05 psia resulting from linearity.

e. Pack voltages, which exceed 10 volts, are attenuated by resistors to the extent that the scanner system measures a maximum of 10 volts.

3. Calibration:

a. The system was designed for a maximum throughout measurement error of 1.0 millivolt.

b. The digitizers are routinely calibrated off-line; and, when on-line, are compared with a secondary standard reference voltage each scan to insure maximum system accuracy.

C. INTERFACE CONTROLS

The control units for charge and discharge of the cells are controlled by the relays on the Digitial to Resistance (D/R) cards of the ADACS. The D/R cards can control the voltage and current on a power supply up to 1/256 of current or voltage required. Figure B-1 is the wiring diagram for the control unit of a multi-pack configuration and Figure B-2 is the wiring diagram for the control unit for single-pack testing.

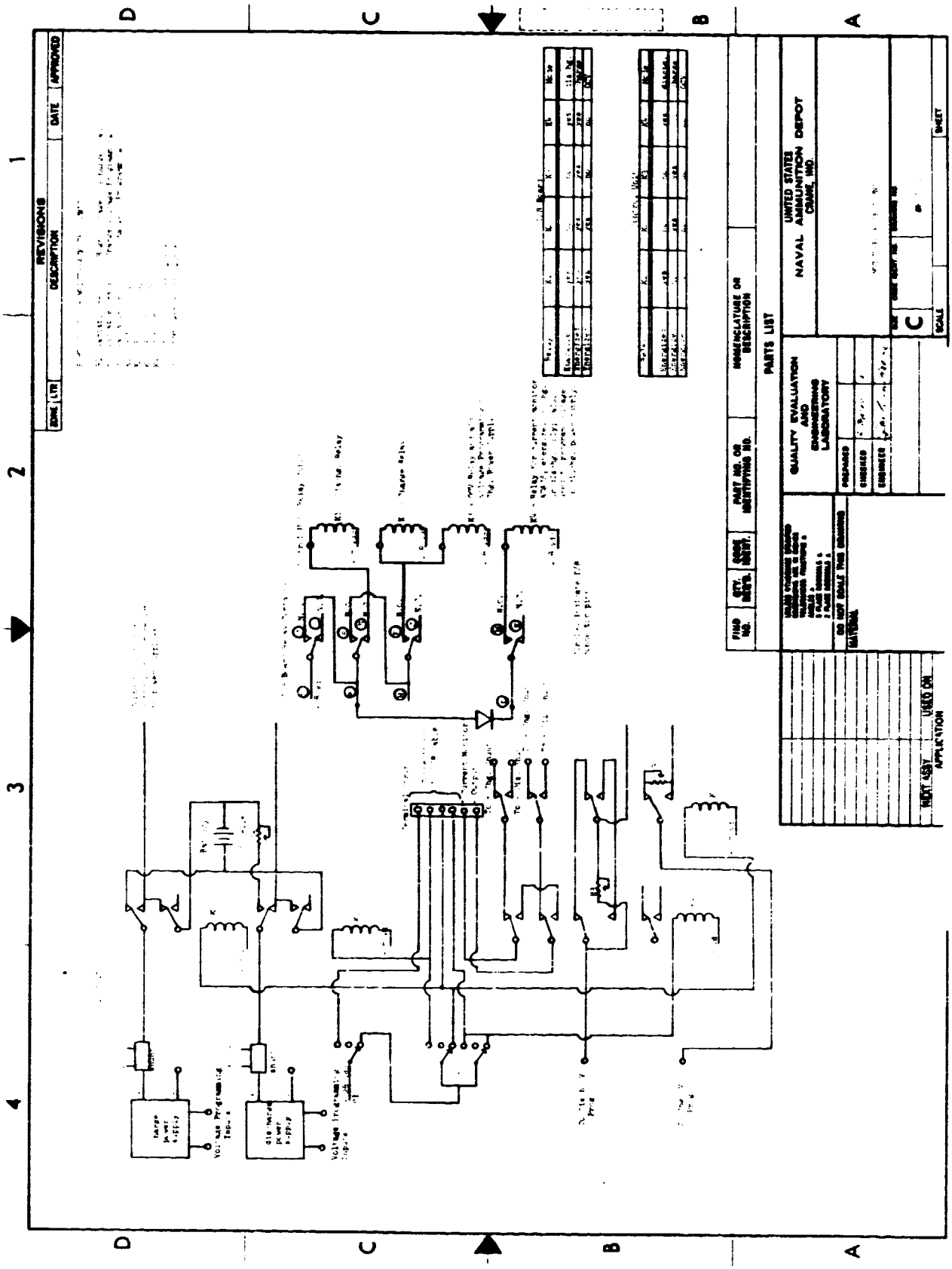


FIGURE B-1 MULTI-PACK TEST UNIT

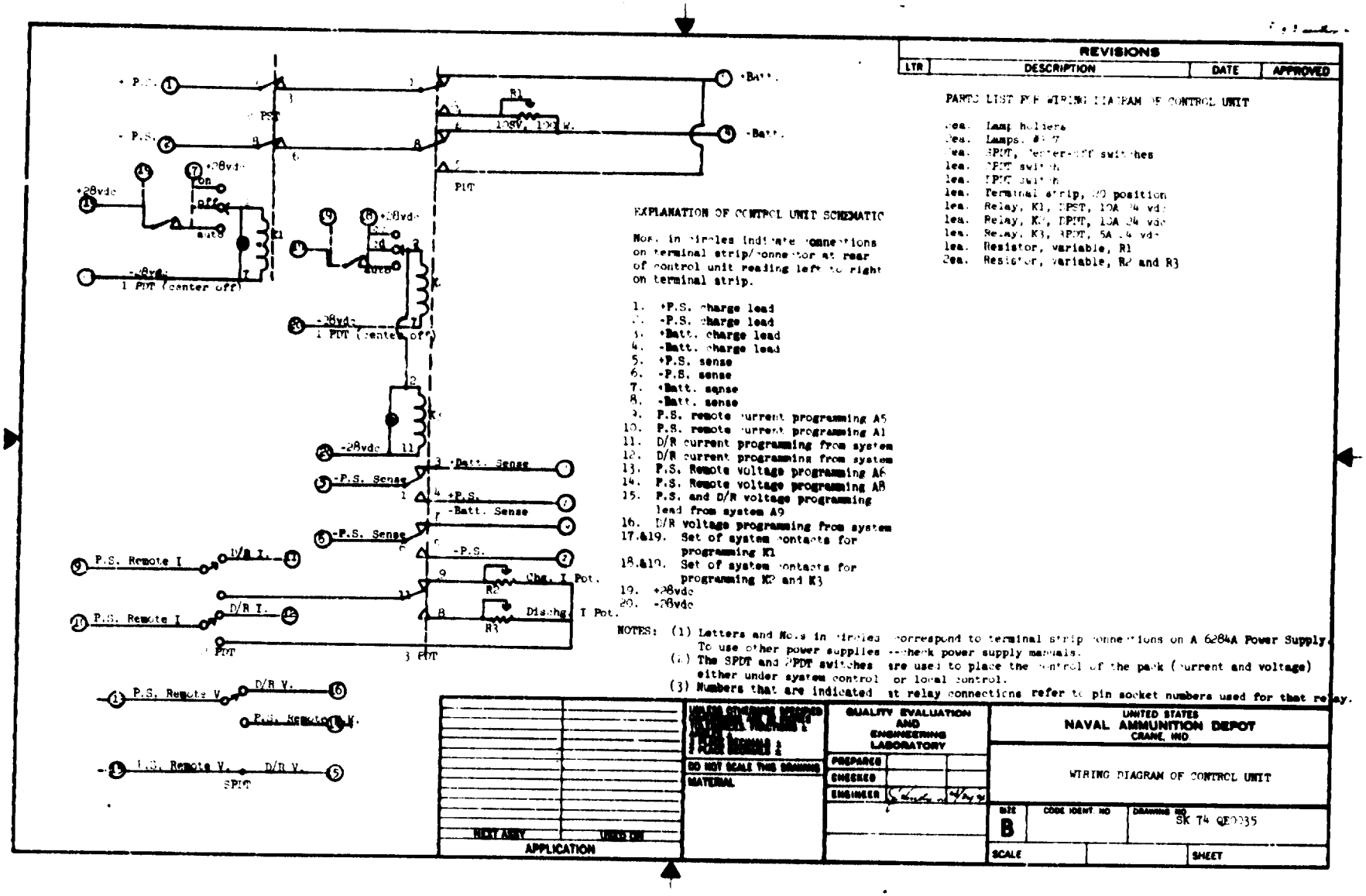


FIGURE B-2 SINGLE PACK CONTROL UNIT

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APPENDIX C

ABBREVIATED PACK TEST ANOMALY SUMMARY

PACK NO.	COMMENT
3N	Cell 2 failed because of high pressdue to being overcharged.
6N	Cell 2 failed because of high pressure due to it being overcharged.
9N	Cells 3, 4 and 5 failed because they were overcharged.
11N	Cells 1 and 2 failed because of high pressure due to being overcharged.
12N	Cells 1 and 2 failed because of pressure when the ambient temperature decreased from 50 to 40°C.
13N	Cells 1 and 5 failed (low voltage) because they did not receive a charge prior to discharge.
15N	Cells 3 and 5 failed (low voltage) because they were not charged the cycle before they failed.
16N	Cell 1 failed because of high pressure (cycle 1003), following a decrease in the ambient temperature from 50 to 41°C.
19N	Cells 3 and 5 failed due to the malfunction of their control which prevented them from being charged on the cycle preceding their low-voltage failure.
22N	Pack was over discharged on cycle 205. The cells were reversed.
27N	Cell 2 failed because of high pressure due to being overcharged (cycle 2252).
28N	Cell 3 was overcharged on cycle 2237 which led to its high pressure failure.
32N	Cell 1 failed when the ambient temperature decreased to 25°C.
40N	Cell 1 was discontinued because of a hardware malfunction which indicated a high pressure.

PACK NO.	COMMENT
50N	Cell 5 did not fail; but was discontinued inadvertently.
51N	Pack failed because the ambient temperature was 57°C, and the cell temperatures exceeded 60°C at the EOC and throughout the discharge.
53N	Cell 3 was inadvertently removed from test on cycle 6676.
55N	Cells 3 and 4 were overcharged, from cycle 429 to 432, due to the pack being placed on charge when cell 5 failed during discharge. Cells 1 and 2 failed because of pressure due to a decrease in the ambient temperature.
65N	Cells 1 and 3 were removed because of high pressure caused by being overcharged.
67N	Failure of cell 1 was caused by a broken monitor lead on its pressure transducer. Cells 2 and 3 were severely reversed. They developed internal shorts and were removed from the circuit on cycle 9310.
69N	Cell 1 failed on cycle 592, because of low voltage caused by its not being recharged on the previous cycle.
71N	Cell 2 failed due to high pressure because it was overcharged.
72N	Cell 3 had been on open-circuit three days prior to cycle 1352 in which it developed high pressure.
73N	Cell 2 was inadvertently removed for high pressure on cycle 3501.
74N	Cell 4 had been on open-circuit 5 days prior to cycle 1802. Cell 5 shorted during charge of cycle 1810 due to over-charges the previous cycle. Cell 1 failed because of high pressure on cycle 1due to overcharge.
77N	A malfunction of the pack's control unit allowed the cells to severely reverse on cycle 1909.
78N	Cells 2, 4 and 5 were overcharged when cell 3 failed.
81N	Cell 1 failed following a 19-day open circuit period.
82N	All the cells were sevelely reversed on cycle 678 because of a hardware malfunction.

APPENDIX D

POST CYCLE TEST PROCEDURE

I. CELL REMOVAL

a. On cycle that cell is to be removed, diconnect cell from pack at end of charge. Immediately discharge at matrix rate and matrix temperature to 0.50 volts.

b. Short cell with a 0.5-ohm resistor at matrix temperature for 16 hours. Record pressure decay if greater than 15 psia.

c. Remove resistor and charge cell at matrix temperature and matrix rate to matrix overcharge. Measure internal impedance within 5 minutes after end of charge.

d. Open circuit stand for 10 minutes.

e. Discharge at matrix rate to 0.50 volts. Measure internal impedance within 5 minutes after the end of discharge.

f. Short cell with a 0.5-ohm resistor for 16 hours.

g. Remove resistor and charge cell at matrix temperature at 600 ma. for 16 hours at 1.60 volts limit. Measure internal impedance within 5 minutes after end of charge.

h. Open circuit stand for 1 hour.

i. Discharge at 3.0 amperes to 0.75 volts. Open circuit cell at the cutoff voltage. Measure internal impedance within 5 minutes after end of discharge.

j. Short cells with a 0.5-ohm resistor.

k. Within 16 hours condition cell for 8 to 72 hours at 20 ±2° C.

II. CHARGE EFFICIENCY 20 ±2° C.

a. Remove resistor and charge at 150 ma. for 20 hours.

b. Open circuit stand for 1 hour.

c. Discharge cell at 3.0 amperes to 0.75 volts. Open circuit at cutoff voltage.

III. INTERNAL SHORT TEST

a. Discharge the cell with a 0.5 ±3% resistor for 16 hours. Measure the decay voltage every hour during the 16 hour period.

b. Remove resistor and measure recovery voltage every 30 minutes until cell voltage is equal to or greater than 1.15 volts. Then read once every hour for the remaining time. Total time of test to be 24 hours.

IV. CAPACITY TEST 20 ±2° C.

a. Charge at 600 ma. for 16 hours at 1.60 volts. Set pressure cuttoff at 100 psia. Measure internal impedance within 5 minutes after end of charge.

b. Open circuit stand for one hour. Record pressure decay during the open circuit stand.

c. Discharge at 3.0 amperes to 0.75 volts. Measure internal impedance during the first five minutes and within 5 minutes after the end of discharge. Record pressure decay during discharge at 15 minute intervals.

d. Short cell with a 0.5-ohm resistor for 16 hours. During this period, record pressure decay every hour if end of discharge pressure is greater than 15 psia.

e. Condition cells at 0 ±2° C. for 16 hours.

f. Remove resistor and charge cells at 300 ma. for 72 hours at 0 ±2° C. Record voltages and pressures at one hour intervals and at end of charge. Set pressure cut off at 100 psia.

g. Discharge cells at 3.0 amperes to 0.75 volts.

h. Short cell with 0.5-ohm resistor for 16 hours.

i. Remove resistor and solder short across cell. Short at 20 ±2° C.

V. PERFORM FAILURE ANALYSIS WHEN SPECIFIED.

APPENDIX E

HISTOGRAMS

Each cell is identified in the histogram by the Pack No. and cell position. The identification is printed as PPNC where PPN is the pack number such as 58N and C is the cell position in the pack (1 to 8). Leading zeroes in the pack number have been deleted and uncycled cells appear as "0" in the histogram. A very limited amount of study has been done on the manufacturers and baseline data of the histogram, but so far nothing has been found that would distinguish a good cell from a bad cell. Table E-1 lists the 72 data points used in the histogram.

TABLE E-1

CORRELATION DATA FILE

VAR. NO.	VARIABLE	TITLE
1	AVEH2	GAS SAMPLING AVE PERCENT H2
2	AVEO2	GAS SAMPLING AVE PERCENT O2
3	AVEN2	GAS SAMPLING AVE PERCENT N2
4	CDOH	CHEMICAL ANALYSIS-NEGATIVE PLATE CDOH2 (G)
5	CDOHAH	CHEMICAL ANALYSIS-NEGATIVE PLATE CDOH2 (AH)
6	CD	CHEMICAL ANALYSIS-NEGATIVE PLATE CD (G)
7	CDAH	CHEMICAL ANALYSIS-NEGATIVE PLATE CD (AH)
8	NIOH	CHEMICAL ANALYSIS-POSITIVE PLATE NIOH (G)
9	NIOHAH	CHEMICAL ANALYSIS-POSITIVE PLATE NIOH (AH)
10	NI	CHEMICAL ANALYSIS-POSITIVE PLATE METALLIC NICKEL (G)
12	PPCAP	ELECTROCHEMICAL ANALYSIS POSITIVE PLATE CAPACITY (AH)
13	RNPCAP	ELECTROCHEMICAL ANALYSIS NEGATIVE PLATE PRECHARGE CAPACITY (AH)
14	POSPLWT	PHYSICAL ANALYSIS POSITIVE PLATE WEIGHT AVERAGE (G)
15	NEGPLWT	PHYSICAL ANALYSIS NEGATIVE PLATE WEIGHT AVERAGE (G)
16	POSPLTH	PHYSICAL ANALYSIS POSITIVE PLATE THICKNESS AVERAGE (CM)
17	NEGPLTH	PHYSICAL ANALYSIS NEGATIVE PLATE THICKNESS AVERAGE (CM)
18	TOTALNEG	CHEMICAL ANALYSIS TOTAL CAPACITY NEGATIVE CELL (AH)
19	TOTALPOS	CHEMICAL ANALYSIS TOTAL CAPACITY POSITIVE CELL (AH)
20	WDIFF	ELECTROLYTE ANALYSIS CORE WET WEIGHT MINUS DRY WEIGHT (G)
21	CELL KOH	ELECTROLYTE ANALYSIS CELL EXTRACT KOH (G)
22	CELLK2CO	ELECTROLYTE ANALYSIS CELL EXTRACT K2CO3 (G)
23	CELCONC	ELECTROLYTE ANALYSIS CELL EXTRACT KOH CONCENTRATION PERCENT WEIGHT
24	CELAMT	ELECTROLYTE ANALYSIS CELL EXTRACT KOH AMOUNT (CC)
25	EOCTEST1	MANUFACTURERS TESTS N01 EOC VOLTAGE (CHG C/2 150MIN 22 DEGREES C)
26	EOCTEST2	MANUFACTURERS TESTS N02 EOC VOLTAGE (CHG C/2 150MIN 22 DEGREES C)
27	EOCTEST3	MANUFACTURERS TESTS N03 EOC VOLTAGE (CHG C/8 12 HR 22 DEGREES C)
28	EOCTEST4	MANUFACTURERS TESTS N04 EOC VOLTAGE (CHG C/10 48 HR 22 DEGREES C)
29	EOCTEST5	MANUFACTURERS TESTS N05 EOC VOLTAGE (CHG C/10 16 HR 22 DEGREES C)
30	EOCTEST6	MANUFACTURERS TESTS N06 EOC VOLTAGE (CHG C/10 16 HR 38 DEGREES C)
31	EOCTEST7	MANUFACTURERS TESTS N07 EOC VOLTAGE (CHG C/20 72 HR 0°C DEGREES C)
32	EOCPRES1	MANUFACTURERS TESTS N01 EOC PRESSURE (CHG C/2 150MIN 22 DEGREES C)
33	EOCPRES2	MANUFACTURERS TESTS N02 EOC PRESSURE (CHG C/2 150MIN 22 DEGREES C)
34	EOCPRES3	MANUFACTURERS TESTS N03 EOC PRESSURE (CHG C/8 12 HR 22 DEGREES C)
35	EOCPRES4	MANUFACTURERS TESTS N04 EOC PRESSURE (CHG C/10 48 HR 22 DEGREES C)
36	EOCPRES5	MANUFACTURERS TESTS N05 EOC PRESSURE (CHG C/10 16 HR 22 DEGREES C)
37	EOCPRES6	MANUFACTURERS TESTS N06 EOC PRESSURE (CHG C/10 16 HR 38 DEGREES C)
38	EOCPRES7	MANUFACTURERS TESTS N07 EOC PRESSURE (CHG C/20 72 HR 0°C DEGREES C)
39	EODCAP 1	MANUFACTURERS TESTS N01 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
40	EODCAP 2	MANUFACTURERS TESTS N02 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
41	EODCAP 3	MANUFACTURERS TESTS N03 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
42	EODCAP 4	MANUFACTURERS TESTS N04 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
43	EODCAP 5	MANUFACTURERS TESTS N05 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
44	EODCAP 6	MANUFACTURERS TESTS N06 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
45	EODCAP 7	MANUFACTURERS TESTS N07 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
46	TEST8	MANUFACTURERS TESTS N08 SHORT TEST (OPEN CIRCUIT VOLTAGE)
47	TEST9	MANUFACTURERS TESTS N09 INTERNAL RESISTANCE (DISCH C/2 FOR 1 HR)
48	TEST9	MANUFACTURERS TESTS N09 INTERNAL RESISTANCE (DISCH C/3.33 FOR 5 MIN)
49	EOCTEST1	BASELINE TESTS NO 1 EOC VOLTAGE (CHG C/20 40 HR 20 DEGREES C)
50	EOCTEST2	BASELINE TESTS NO 2 EOC VOLTAGE (CHG C/10 16 HR 20 DEGREES C)
51	EOCTEST3	BASELINE TESTS NO 3 EOC VOLTAGE (CHG C/40 20 HR 20 DEGREES C)
52	EOCTEST4	BASELINE TESTS NO 4 INTERNAL SHORT TESTS (OPEN CIRCUIT VOLTAGE)
53	EOCTEST5	BASELINE TESTS NO 5 EOC VOLTAGE (CHG C/10 16 HR MATRIX TEMPERATURE)
54	EOCTEST6	BASELINE TESTS NO 6 EOC VOLTAGE (MATRIX TEMPERATURE AND RATE)
55	EOCPRES1	BASELINE TESTS NO 1 EOC PRESSURE (CHG C/20 40 HR 20 DEGREES C)
56	EOCPRES2	BASELINE TESTS NO 2 EOC PRESSURE (CHG C/10 16 HR 20 DEGREES C)
57	EOCPRES3	BASELINE TESTS NO 3 EOC PRESSURE (CHG C/40 20 HR 20 DEGREES C)
58	EOCPRES4	BASELINE TESTS NO 4 INTERNAL SHORT TESTS
59	EOCPRES5	BASELINE TESTS NO 5 EOC PRESSURE (CHG C/10 16 HR MATRIX TEMPERATURE)
60	EOCPRES6	BASELINE TESTS NO 6 EOC PRESSURE (MATIX TEMPERATURE AND RATE)
61	EODCAP 1	BASELINE TESTS NO 1 EOD CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C)
62	EODCAP 2	BASELINE TESTS NO 2 EOD CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C)
63	EODCAP 3	BASELINE TESTS NO 3 EOD CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C)
64	EODCAP 4	BASELINE TESTS NO 4 INTERNAL SHORT TEST (Data for this test not plotted.)
65	EODCAP 5	BASELINE TESTS NO 5 EOD CAPACITY (DISCH C/2 TO .75 V/C MATRIX TEMP)
66	EODCAP 6	BASELINE TESTS NO 6 EOD CAPACITY (DISCH MATRIX RATE * TEMP TO .50 V/C)
67	EODPRES1	BASELINE TESTS NO 1 EOD PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C)
68	EODPRES2	BASELINE TESTS NO 2 EOD PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C)
69	EODPRES3	BASELINE TESTS NO 3 EOD PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C)
70	EODPRES4	BASELINE TESTS NO 4 INTERNAL SHORT TEST (Data for this test not plotted.)
71	EODPRES5	BASELINE TESTS NO 5 EOD PRESSURE (DISCH C/2 TO .75 V/C MATRIX TEMP)
72	EODPRES6	BASELINE TESTS NO 6 EOD PRESSURE (DISCH MATRIX HEAT * TEMP TO .50 V/C)

AVEH2

VARIABLE NO. 1 GAS SAMPLING AVE PERCENT H2 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.60000	82.0000	80.4000	69	34.1362	27.5722

0.	-	8.000	(14)	4N4 6N1 15N4 16N5 23N5 40N3 45N5 57N4 77N2 77N3 77N4 80N4 81N6 81N7
8.000	-	16.00	(14)	8N4 17N4 48N3 54N4 68N3 68N4 68N6 70N3 70N7 70N8 77N1 80N1 80N8 81N8
16.00	-	24.00	(10)	30N4 34N4 36N5 37N3 63N4 68N7 68N8 72N3 79N4 81N5
24.00	-	32.00	(2)	8N2 73N8
32.00	-	40.00	(1)	80N6
40.00	-	48.00	(0)	
48.00	-	56.00	(6)	68N2 69N6 69N7 72N8 76N4 80N5
56.00	-	64.00	(6)	50N2 69N5 72N4 79N1 79N2 80N2
64.00	-	72.00	(8)	68N5 69N4 70N4 72N5 72N6 80N7 81N2 81N3
72.00	-	80.00	(5)	68N1 70N5 70N6 72N2 79N3
80.00	-	88.00	(3)	72N1 72N7 80N3

AVEO2

GAS SAMPLING AVE PERCENT O2

VARIABLE NO. 2 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.100000	37.4000	37.3000	80	6.72625	6.42530

0.	-	3.000	(28)	4N4 6N1 9N2 8N4 12N3 15N4 19N4 27N3 34N4 36N5 38N3 39N4 46N3 48N3 50N2 53N5 54N4 58N1 61N5 62N. 63N4 70N4 70N5 72N1 72N6 80N5 81N4 81N8
3.000	-	6.000	(18)	30N4 35N4 41N4 68N2 68N3 70N6 70N8 72N2 72N7 72N8 73N8 79N1 79N3 79N4 80N1 80N2 80N6 81N2
6.000	-	9.000	(6)	28N1 57N4 68N1 68N6 76N4 80N3
9.000	-	12.00	(15)	37N3 45N5 58N5 68N7 68N8 69N4 69N6 69N7 70N7 72N3 77N3 79N2 80N4 80N7 81N7
12.00	-	15.00	(4)	68N4 69N5 77N2 80N8
15.00	-	18.00	(4)	56N5 72N4 77N5 81N6
18.00	-	21.00	(4)	66N8 77N4 87N1 87N2
21.00	-	24.00	(0)	
24.00	-	27.00	(0)	
27.00	-	30.00	(0)	
30.00	-	33.00	(0)	
33.00	-	36.00	(0)	
36.00	-	39.00	(1)	70N3

AVEN2

VARIABLE NO. 3 GAS SAMPLING AVE PERCENT N2 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
15.5000	99.5000	84.0000	89	64.5899	26.7023

8.000	- 16.00	(2)	72N1 72N7	
16.00	- 24.00	(11)	68N1 69N4 70N5 70N6 72N2 72N4 72N5 79N3 80N3 80N7 81N2	
24.00	- 32.00	(6)	68N5 69N5 70N4 72N6 79N2 81N3	
32.00	- 40.00	(3)	76N4 79N1 80N2	
40.00	- 48.00	(5)	6N1 68N2 69N6 69N7 72N8	
48.00	- 56.00	(1)	80N5	
56.00	- 64.00	(6)	28N1 31N4 54N4 70N3 80N6 81N8	
64.00	- 72.00	(6)	68N4 68N7 68N8 72N3 73N8 80N1	
72.00	- 80.00	(14)	15N4 36N5 37N3 45N5 50N2 66N8 70N7 77N2 79N4 80N8 81N5 81N6 87N1 87N2	
80.00	- 88.00	(15)	8N2 17N4 30N4 53N5 56N5 63N4 68N3 68N6 70N8 77N1 77N3 77N4 77N5 80N4 81N7	
88.00	- 96.00	(16)	4N4 12N3 16N5 19N4 23N5 27N3 34N4 38N3 39N4 40N3 48N3 57N4 58N1 61N5 62N3 81N4	
96.00	- 104.0	(4)	8N4 35N4 41N4 46N3	

CDOH

VARIABLE NO. 4 CHEMICAL ANALYSIS-NEGATIVE PLATE CDOH2 (G) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.31000	4.67000	3.35000	191	3.37754	.653061

1.200	-	1.500	(1)	74N2
1.500	-	1.800	(1)	71N2
1.800	-	2.100	(4)	71N1 71N5 73N2 78N1
2.100	-	2.400	(7)	57N4 71N3 71N6 72N4 73N3 75N2 76N4
2.400	-	2.700	(17)	8N2 16N5 40N3 70N1 70N2 72N1 72N2 73N1 73N4 73N5 74N3 75N1 75N5 76N1 76N2 76N6 79N1
2.700	-	3.000	(24)	12N3 23N5 46N3 67N1 68N2 68N6 69N4 70N5 71N4 71N7 72N3 72N5 73N6 73N8 74N4 74N5 75N3 76N3 76N5 78N5 80N4 81N3 81N4 81N5
3.000	-	3.300	(33)	4N4 6N1 15N4 31N4 34N4 35N4 39N4 58N1 63N4 67N4 67N5 68N1 68N4 68N5 70N3 70N4 70N6 70N7 75N4 75N6 75N7 77N5 77N6 78N2 78N3 78N4 79N2 79N7 80N1 80N3 80N5 81N1 81N6
3.300	-	3.600	(27)	8N4 17N4 27N3 35N1 36N5 56N5 61N5 62N3 65N1 65N3 67N7 68N3 68N7 68N8 69N1 71N8 74N1 74N8 77N3 77N6 77N7 79N3 79N6 80N2 80N7 81N7 87N1
3.600	-	3.900	(35)	19N4 30N4 38N3 41N4 45N5 48N3 50N2 54N4 65N2 65N4 65N5 65N8 67N6 67N8 69N2 69N5 69N6 69N7 70N8 73N7 74N6 74N7 76N7 77N1 77N2 77N4 78N6 78N7 78N8 79N4 79N5 80N6 80N8 81N2 81N8
3.900	-	4.200	(17)	10N4 28N1 65N6 65N7 66N8 69N3 72N6 72N7 72N8 74N8 79N8 82N1 82N2 89N3 90N3 92N2 95N3
4.200	-	4.500	(23)	0 0 0 0 0 0 0 0 0 0 0 82N5 87N2 89N1 89N2 90N1 90N2 91N1 91N2 91N3 92N1 92N3 95N2
4.500	-	4.800	(2)	0 0

CDOHAH

VARIABLE NO. 5 CHEMICAL ANALYSIS-NEGATIVE PLATE CDOH2 (AH) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.480000	1.71000	1.23000	191	1.23654	.238947

.4000	-	.5000	(1)	74N2
.5000	-	.6000	(0)	
.6000	-	.7000	(2)	71N1 71N2
.7000	-	.8000	(4)	71N5 73N2 73N3 78N1
.8000	-	.9000	(9)	57N4 70N2 71N3 71N6 72N4 75N1 75N2 75N5 76N4
.9000	-	1.000	(14)	8N2 16N5 40N3 70N1 72N1 72N2 73N1 73N4 73N5 74N3 76N1 76N2 76N6 79N1
1.000	-	1.100	(24)	12N3 23N5 46N3 67N1 68N2 68N6 69N4 70N5 71N4 71N7 72N3 72N5 73N6 73N8 74N4 74N5 75N3 76N3 76N5 78N5 80N4 81N3 81N4 81N5
1.100	-	1.200	(32)	4N4 6N1 15N4 31N4 34N4 35N4 39N4 58N1 63N4 67N4 67N5 68N1 68N4 68N5 70N3 70N4 70N6 70N7 75N4 75N6 75N7 77N5 77N8 78N3 78N4 79N2 79N7 80N1 80N3 80N5 81N1 81N6
1.200	-	1.300	(23)	17N4 27N3 36N5 56N5 65N1 65N3 67N7 68N3 68N7 68N8 69N1 71N8 74N1 74N8 77N3 77N6 77N7 78N2 79N3 79N6 80N2 81N7 87N1
1.300	-	1.400	(34)	8N4 19N4 30N4 35N1 38N3 41N4 45N5 48N3 50N2 61N5 62N3 65N2 65N4 65N5 65N8 67N8 69N2 69N5 69N6 70N8 74N7 76N7 77N1 77N2 77N4 78N6 78N8 79N4 79N5 80N6 80N7 80N8 81N2 81N8
1.400	-	1.500	(16)	10N4 28N1 54N4 65N6 65N7 66N8 67N6 69N7 72N6 72N7 72N8 73N7 74N6 76N8 78N7 92N2
1.500	-	1.600	(17)	0 0 69N3 79N8 82N1 82N2 82N5 87N2 89N3 90N1 90N2 90N3 91N1 91N2 92N3 95N2 95N3
1.600	-	1.700	(14)	0 0 0 0 0 0 0 0 0 0 89N1 89N2 91N3 92N1
1.700	-	1.800	(1)	0

CO

VARIABLE NO. 6 CHEMICAL ANALYSIS-NEGATIVE PLATE CD (G) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.500000E-01	1.77000	1.72000	191	.708325	.453159

0. - .1000E+00	(12)	0	0	0	0	82N1	82N2	82N5	87N1	87N2	89N3	92N3	95N2												
.1000E+00 - .2000	(22)	0	0	0	0	0	0	0	0	0	28N1	56N5	72N7	89N1	89N2	90N1	90N2	90N3	91N1	91N2	91N3	92N1	95N3		
.2000 - .3000	(9)	45N5	65N6	65N7	66N8	72N8	76N8	77N5	79N8	92N2															
.3000 - .4000	(13)	10N4	48N3	61N5	62N3	65N2	65N4	65N5	67N6	69N3	72N6	74N6	77N4	80N8											
.4000 - .5000	(19)	17N4	19N4	27N3	30N4	38N3	50N2	54N4	67N8	68N7	69N2	69N4	69N6	69N7	73N7	77N2	79N5	80N6	81N2	81N8					
.5000 - .6000	(14)	6N1	8N4	31N4	35N4	41N4	65N8	67N4	69N5	74N7	77N1	77N6	78N7	79N4	81N7										
.6000 - .7000	(11)	4N4	12N3	36N5	39N4	65N1	65N3	67N5	76N7	77N7	78N6	80N7													
.7000 - .8000	(13)	15N4	68N3	68N5	69N1	70N4	70N5	70N8	71N7	71N8	77N3	78N2	78N8	79N6											
.8000 - .9000	(10)	16N5	35N1	67N7	68N8	72N1	78N3	79N3	80N3	80N5	81N6														
.9000 - 1.000	(11)	57N4	58N1	68N1	74N8	75N4	75N7	77N8	78N4	79N2	79N7	81N1													
1.000 - 1.100	(17)	8N2	23N5	34N4	40N3	46N3	68N4	68N6	70N6	70N7	71N4	72N5	73N6	74N1	74N4	74N5	76N5	80N4							
1.100 - 1.200	(10)	63N4	67N1	68N2	72N3	73N5	75N6	76N1	76N3	78N5	80N1														
1.200 - 1.300	(4)	70N3	75N3	76N6	81N5																				
1.300 - 1.400	(6)	70N1	72N4	73N1	73N4	73N8	74N2																		
1.400 - 1.500	(11)	70N2	71N3	71N6	72N2	75N5	76N2	76N4	78N1	79N1	81N3	81N4													
1.500 - 1.600	(4)	71N1	71N5	75N1	80N2																				
1.600 - 1.700	(3)	71N2	73N2	74N3																					
1.700 - 1.800	(2)	73N3	75N2																						

CDAH

VARIABLE NO. 7 CHEMICAL ANALYSIS-NEGATIVE PLATE CD (AH)
BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.200000E-01	.650000	.630000	191	.259058	.165730

0. -	.6000E-01	(26)	0 0 0 0 0 0 0 0 0 0 28N1 72N7 82N1 82N2 82N5 87N1 87N2 89N1 89N2 89N3 90N1 90N2 92N1 92N3 95N2 95N3	
.6000E-01 -	.1200	(20)	0 0 0 45N5 56N5 61N5 62N3 65N6 65N7 66N8 69N3 72N8 76N8 77N5 79N8 90N3 91N1 91N2 91N3 92N2	
.1200 -	.1800	(25)	10N4 17N4 19N4 27N3 30N4 48N3 54N4 65N2 65N4 65N5 67N6 67N8 68N7 69N2 69N6 69N7 72N6 73N7 74N6 77N2 77N4 79N5 80N6 80N8 81N8	
.1800 -	.2400	(25)	5N1 8N4 12N3 31N4 35N4 36N5 38N3 39N4 41N4 50N2 65N3 65N8 67N4 67N5 69N4 69N5 74N7 76N7 77N1 77N6 78N6 78N7 79N4 81N2 81N7	
.2400 -	.3000	(19)	4N4 15N4 35N1 65N1 68N3 68N5 69N1 70N4 70N5 70N8 71N7 71N8 77N3 77N7 78N2 78N8 79N3 79N6 80N7	
.3000 -	.3600	(14)	16N5 57N4 58N1 67N7 68N1 68N8 72N1 75N4 78N3 78N4 79N7 80N3 80N5 81N6	
.3600 -	.4200	(28)	8N2 23N5 34N4 40N3 46N3 67N1 68N2 68N4 68N6 70N6 70N7 71N4 72N3 72N5 73N6 74N1 74N4 74N5 74N8 75N6 75N7 76N5 77N8 78N5 79N2 80N1 80N4 81N1	
.4200 -	.4800	(8)	63N4 70N3 73N5 75N3 76N1 76N3 76N6 81N5	
.4800 -	.5400	(13)	70N1 70N2 71N6 72N4 73N1 73N4 73N8 74N2 75N5 76N2 76N4 79N1 81N4	
.5400 -	.6000	(10)	71N1 71N2 71N3 71N5 72N2 74N3 75N1 78N1 80N2 81N3	
.6000 -	.6600	(3)	73N2 73N3 75N2	

NIOH

VARIABLE NO. 8

CHEMICAL ANALYSIS-POSITIVE PLATE NIOH (G)
BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
2.56000	4.19000	1.63000	151	3.47225	.248434

2.500	-	2.600	(2)	67N8 77N5
2.600	-	2.700	(0)	
2.700	-	2.800	(0)	
2.800	-	2.900	(2)	0 0
2.900	-	3.000	(1)	70N6
3.000	-	3.100	(1)	74N8
3.100	-	3.200	(9)	0 0 65N8 69N6 72N6 72N7 78N8 87N2 91N1
3.200	-	3.300	(18)	0 0 69N4 69N5 70N8 72N8 74N2 78N7 79N6 80N5 87N1 87N3 89N1 90N1 90N2 92N2 92N3 95N2
3.300	-	3.400	(19)	0 0 67N4 68N8 69N2 69N3 70N7 74N4 74N7 75N8 76N1 77N3 78N6 80N2 80N6 80N7 81N8 82N5 95N3
3.400	-	3.500	(29)	65N1 65N2 65N6 65N7 67N1 67N5 67N6 67N7 70N5 71N8 72N3 73N1 74N6 75N4 75N5 75N7 76N4 76N8 78N1 78N4 80N1 80N3 80N4 81N2 81N3 81N6 81N7 82N2 92N1
3.500	-	3.600	(22)	0 10N4 66N8 68N1 68N3 68N4 69N1 70N1 70N4 71N2 71N6 72N1 73N8 74N5 77N2 77N6 77N7 77N8 79N7 79N8 80N8 82N1
3.600	-	3.700	(20)	0 0 68N6 69N7 70N2 71N1 71N3 71N4 71N5 72N2 73N2 73N6 73N7 74N1 75N2 75N3 76N6 78N2 79N2 90N3
3.700	-	3.800	(20)	0 0 29N5 35N1 68N2 68N7 71N7 72N4 72N5 73N5 74N3 75N6 76N3 76N7 77N1 77N4 78N3 79N1 79N3 79N5
3.800	-	3.900	(4)	14N5 68N5 76N2 78N5
3.900	-	4.000	(2)	75N1 76N5
4.000	-	4.100	(1)	73N4
4.100	-	4.200	(1)	73N3

NIOHAM

VARIABLE NO. 9 CHEMICAL ANALYSIS-POSITIVE PLATE NIOH (AH) BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.740000	1.21000	.470000	151	1.00318	.718087E-01

.7200	-	.7600	(2)	67N8 77N5
.7600	-	.8000	(0)	
.8000	-	.8400	(1)	0
.8400	-	.8800	(3)	0 70N6 74N8
.8800	-	.9200	(7)	0 0 65N8 72N7 78N8 87N2 91N1
.9200	-	.9600	(21)	0 0 69N4 69N5 69N6 70N8 72N6 72N8 74N2 74N4 78N7 79N6 80N5 87N1 87N3 89N1 90N1 90N2 92N2 92N3 95N2
.9600	-	1.000	(36)	0 0 65N1 65N2 65N6 65N7 67N1 67N4 67N5 68N8 69N2 69N3 70N5 70N7 71N8 74N6 74N7 75N5 75N8 76N1 76N8 77N3 78N1 78N6 80N1 80N2 80N6 80N7 81N3 81N6 81N7 81N8 82N2 82N5 92N1 95N3
1.000	-	1.040	(30)	0 10N4 66N8 67N6 67N7 68N3 68N4 69N1 70N1 70N4 71N2 71N6 72N1 72N3 73N1 73N8 74N5 75N4 75N7 76N4 77N2 77N6 78N4 79N7 79N8 80N3 80N4 80N8 81N2 82N1
1.040	-	1.080	(29)	0 0 35N1 68N1 68N6 68N7 69N7 70N2 71N1 71N3 71N4 71N5 72N2 73N2 73N6 73N7 74N1 74N3 75N2 75N3 76N6 77N1 77N4 77N7 77N8 78N2 79N2 79N3 90N3
1.080	-	1.120	(15)	0 0 14N5 29N5 68N2 71N7 72N4 72N5 73N5 75N6 76N3 76N7 78N3 79N1 79N5
1.120	-	1.160	(5)	68N5 75N1 76N2 76N5 78N5
1.160	-	1.200	(1)	73N4
1.200	-	1.240	(1)	73N3

NI

VARIABLE NO. 10 CHEMICAL ANALYSIS-POSITIVE PLATE METALLIC NICKEL (G) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.29000	2.83000	1.54000	151	1.79212	.183425

1.200	-	1.300	(1)	73N3
1.300	-	1.400	(1)	73N4
1.400	-	1.500	(4)	0 78N5 79N2 79N5
1.500	-	1.600	(13)	67N8 68N4 68N5 70N6 72N2 75N1 75N6 76N2 76N3 76N5 78N3 80N4 90N3
1.600	-	1.700	(17)	29N5 71N1 71N2 71N3 72N4 74N1 74N3 74N5 75N2 75N[illegible] 76N6 77N6 78N2 79N3 79N8 80N2 81N7
1.700	-	1.800	(42)	0 10N4 35N1 65N6 66N8 67N6 68N1 68N3 68N6 68N7 69N1 69N6 70N2 70N4 70N5 70N7 71N4 71N6 71N7 72N1 72N5 72N7 72N8 73N1 73N2 73N5 73N6 73N7 73N8 75N3 75N4 76N4 76N7 77N4 77N8 79N1 79N[illegible] 80N1 80N3 80N6 81N8 90N2
1.800	-	1.900	(38)	0 0 0 65N1 65N2 65N7 67N7 68N2 68N8 69N2 69N4 69N5 70N1 70N8 72N3 72N6 74N4 74N7 75N7 75N8 76N1 76N8 77N1 77N2 77N3 77N7 78N1 78N8 79N6 80N5 80N7 81N6 82N1 82N2 87N1 87N3 95N2 95N3
1.900	-	2.000	(23)	0 0 0 0 67N1 67N4 67N5 69N3 69N7 71N5 74N2 74N6 74N8 78N6 78N7 80N8 81N2 81N3 82N5 87N2 89N1 90N1 92N3
2.000	-	2.100	(8)	0 0 0 14N5 71N8 91N1 92N1 92N2
2.100	-	2.200	(1)	0
2.200	-	2.300	(1)	65N8
2.300	-	2.400	(1)	77N5
2.400	-	2.500	(0)	
2.500	-	2.600	(0)	
2.600	-	2.700	(0)	
2.700	-	2.800	(0)	
2.800	-	2.900	(1)	78N4

NPCAP

VARIABLE NO. 11 BIOSTATISTICAL ANALYSIS NEGATIVE PLATE CAPACITY (AH)

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.340000	1.290000	.950000	155	.909697	.151534

.2700	-	.3600	(1)	75N4
.3600	-	.4500	(2)	68N4 74N4
.4500	-	.5400	(1)	74N5
.5400	-	.6300	(3)	70N2 72N4 72N6
.6300	-	.7200	(8)	68N3 70N1 72N3 72N5 76N4 78N4 79N1 80N4
.7200	-	.8100	(22)	0 0 29N5 66N8 68N2 69N6 70N5 71N6 72N2 74N8 75N1 75N2 77N1 78N2 78N7 79N5 79N8 80N2 81N1 81N2 81N3 81N5
.8100	-	.9000	(32)	0 65N8 67N1 70N3 70N6 70N8 71N2 71N4 71N5 71N7 71N8 72N1 72N7 73N2 73N3 73N5 73N7 74N1 74N2 74N6 75N6 75N2 76N5 76N6 78N6 79N4 79N6 80N1 80N3 80N5 81N4 87N2
.9000	-	.9900	(43)	0 0 0 0 35N1 65N1 65N2 65N4 65N5 65N6 65N7 67N4 67N6 68N5 68N6 68N8 69N5 70N7 71N1 71N3 72N8 73N1 73N4 73N6 73N8 74N3 75N3 75N4 75N7 76N1 76N3 76N7 77N4 77N5 77N8 78N3 78N5 78N8 79N3 80N7 81N6 81N8 87N1
.9900	-	1.080	(27)	0 0 0 0 10N4 65N3 67N8 68N1 68N7 69N1 69N2 69N3 69N4 76N8 77N2 77N3 77N6 78N1 79N2 79N7 80N6 80N8 81N7 82N5 89N1 89N2 91N2
1.080	-	1.170	(19)	69N7 74N7 75N5 75N8 77N7 82N1 82N2 87N3 89N3 90N1 90N2 90N3 91N1 91N3 92N1 92N2 92N3 95N2 95N3
1.170	-	1.260	(5)	0 0 0 14N5 67N7
1.260	-	1.350	(2)	0 0

PPCAP

VARIABLE NO. 12 ELECTROCHEMICAL ANALYSIS POSITIVE PLATE CAPACITY (AH) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.580000	.950000	.370000	163	.779693	.692850E-01

.5700	-	.6000	(2)	70N1 81N4
.6000	-	.6300	(1)	74N1
.6300	-	.6600	(6)	67N1 81N1 81N3 81N5 91N1 91N2
.6600	-	.6900	(6)	0 0 67N4 91N8 89N1 89N2
.6900	-	.7200	(13)	0 0 0 0 65N7 67N6 67N8 69N3 78N4 89N3 92N1 95N2 95N3
.7200	-	.7500	(18)	0 0 65N1 65N8 69N4 70N7 71N1 72N7 74N3 77N1 78N8 80N8 81N2 82N1 87N1 87N3 91N3 92N2
.7500	-	.7800	(29)	65N2 65N3 65N5 68N6 69N5 69N6 69N7 70N3 70N5 70N8 71N3 71N8 73N1 73N6 73N7 73N8 74N2 74N6 75N8 78N2 78N3 78N6 78N7 80N1 81N6 81N7 90N1 90N2 92N3
.7800	-	.8100	(25)	0 0 35N1 65N4 65N5 67N7 68N1 68N7 70N6 71N2 71N6 72N3 72N6 73N2 74N4 74N8 75N7 76N1 77N3 77N5 79N4 79N7 80N4 80N7 90N3
.8100	-	.8400	(30)	0 0 0 66N8 68N6 70N2 70N4 71N4 71N5 71N7 72N1 72N5 73N3 73N5 74N5 74N7 75N2 75N3 75N6 76N5 76N6 76N8 78N5 79N1 79N3 79N5 79N8 80N3 80N5 87N2
.8400	-	.8700	(15)	0 0 0 68N2 68N5 69N2 70N1 72N2 72N4 72N8 75N5 76N2 77N4 79N2 80N6 82N5
.8700	-	.9000	(11)	10N4 14N5 73N4 75N1 75N4 76N3 76N7 77N2 77N8 79N6 82N2
.9000	-	.9300	(5)	29N5 58N3 68N4 69N1 77N7
.9300	-	.9600	(1)	77N6

RNPCAP

VARIABLE NO. 13 ELECTROCHEMICAL ANALYSIS NEGATIVE PLATE PRECHARGE CAPACITY (AH) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.100000E-01	.470000	.460000	141	.147660	.108533

0. -	.4000E-01	(18)	0 0 0	65N2 69N7 70N5 72N7 77N3 77N5 78N6 79N5 79N8 82N2 87N1 87N2 90N1 90N2 90N3
.4000E-01 -	.8000E-01	(25)	0 0 0 0 0	10N4 68N1 68N2 68N3 68N4 69N1 69N2 69N3 70N6 74N8 76N8 77N1 77N4 80N2 80N4 81N3 91N1 91N2 91N3 92N1
.8000E-01 -	.1200	(19)	0	29N5 65N1 65N5 65N7 68N7 68N8 70N7 72N1 72N2 74N1 76N7 77N2 78N2 79N6 80N6 81N7 92N2 92N3
.1200 -	.1600	(24)		65N4 65N8 66N8 67N8 68N5 70N8 71N4 72N3 72N5 73N1 73N7 74N2 74N7 75N7 76N1 76N2 76N5 76N6 78N7 78N8 80N3 80N5 80N8 81N6
.1600 -	.2000	(12)		35N1 67N7 68N6 70N3 74N5 76N4 77N8 78N3 79N2 79N3 79N7 81N8
.2000 -	.2400	(13)		14N5 65N3 67N6 70N2 71N7 71N8 72N4 73N3 74N4 77N6 79N1 80N7 81N1
.2400 -	.2800	(10)		67N1 70N1 71N6 73N5 73N6 76N3 78N4 78N5 79N4 81N5
.2800 -	.3200	(11)		73N4 73N8 74N3 75N3 75N4 75N6 75N8 77N7 78N1 80N1 81N4
.3200 -	.3600	(2)		71N1 71N2
.3600 -	.4000	(2)		71N3 73N2
.4000 -	.4400	(2)		71N5 75N1
.4400 -	.4800	(3)		67N4 75N2 75N5

POSPLWT

PHYSICAL ANALYSIS POSITIVE PLATE WEIGHT AVERAGE (G)
BY PACK.CELL POSITION

VARIABLE NO. 14

MIN	MAX	RANGE	N	MEAN	STD. DEV.
6.83000	7.97000	1.14000	200	7.23345	.234835

6.800	-	6.900	(9)	0 87N3 89N1 89N2 90N3 91N1 91N2 92N2 95N3
6.900	-	7.000	(21)	0 0 0 0 0 0 0 38N3 41N4 66N8 69N4 69N5 69N6 72N6 72N8 89N3 90N2 91N3 92N1 92N3 95N2
7.000	-	7.100	(22)	46N3 56N5 65N8 67N7 67N8 69N7 70N7 70N8 72N7 73N8 74N7 78N8 79N7 79N8 80N6 80N7 81N7 81N8 82N1 82N2 82N5 90N1
7.100	-	7.200	(37)	0 29N5 65N5 65N6 65N7 67N6 68N7 68N8 69N1 69N2 69N3 70N5 70N6 71N8 72N1 73N6 73N7 74N1 74N2 74N5 74N6 74N8 75N6 75N7 77N1 77N3 77N4 77N5 77N6 77N7 77N8 78N6 80N2 80N4 80N5 80N8 81N2
7.200	-	7.300	(51)	0 0 0 12N3 65N1 65N2 65N3 65N4 67N1 67N4 67N5 68N1 68N4 68N6 70N1 70N2 70N3 70N4 71N1 71N2 71N3 71N6 71N7 72N2 72N3 72N4 73N1 74N3 74N4 75N2 75N3 75N4 75N5 75N8 76N4 76N6 76N8 77N2 78N1 78N2 78N3 78N4 78N5 76N7 79N3 79N4 79N5 79N6 81N1 81N3 87N2
7.300	-	7.400	(22)	4N4 10N4 35N1 35N4 57N4 68N2 68N3 68N5 71N4 71N5 72N5 73N2 75N1 76N1 79N1 79N2 80N1 80N3 81N4 81N5 81N6 87N1
7.400	-	7.500	(14)	0 15N4 23N5 31N4 34N4 53N5 54N4 73N3 73N4 73N5 76N2 76N3 76N5 76N7
7.500	-	7.600	(4)	0 0 48N3 62N3
7.600	-	7.700	(6)	0 8N4 14N5 19N4 36N5 58N1
7.700	-	7.800	(7)	17N4 27N3 28N1 37N3 39N4 40N3 61N5
7.800	-	7.900	(5)	6N1 16N5 30N4 45N5 50N2
7.900	-	8.000	(2)	8N2 63N4

NEGPLWT

VARIABLE NO. 15 PHYSICAL ANALYSIS NEGATIVE PLATE WEIGHT AVERAGE (G)
BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
7.23000	8.92000	1.69000	200	7.98825	.316584

7.200	-	7.300	(1)	71N2
7.300	-	7.400	(1)	71N1
7.400	-	7.500	(6)	67N4 67N5 71N3 71N5 71N7 76N1
7.500	-	7.600	(9)	16N5 67N1 71N6 73N2 73N3 73N4 73N5 74N3 76N4
7.600	-	7.700	(20)	70N2 71N4 73N1 74N2 74N5 75N1 75N5 76N2 76N3 76N5 76N6 78N1 78N2 78N3 78N4 78N5 80N1 81N1 81N4 81N5
7.700	-	7.800	(19)	12N3 31N4 35N4 65N1 65N2 65N3 65N5 70N1 70N5 74N1 74N4 75N2 75N4 75N6 76N7 79N1 80N3 80N4 81N3
7.800	-	7.900	(27)	8N2 46N3 56N5 62N3 65N4 68N3 68N4 68N5 68N6 70N3 70N4 70N6 72N1 72N3 72N4 72N5 73N6 73N8 75N3 77N6 77N7 79N3 79N4 80N2 80N5 81N6 87N1
7.900	-	8.000	(32)	4N4 6N1 15N4 17N4 23N5 27N3 40N3 65N7 65N8 67N6 67N7 68N1 68N2 68N7 69N1 69N7 71N8 72N2 75N7 75N8 76N8 77N1 77N2 77N3 77N4 77N8 79N2 79N6 79N7 80N6 80N7 81N2
8.000	-	8.100	(20)	39N4 45N5 57N4 58N1 63N4 67N8 68N8 70N7 70N8 73N7 74N7 74N8 77N5 78N6 78N7 78N8 79N5 80N8 81N7 81N8
8.100	-	8.200	(16)	30N4 38N3 61N5 65N6 66N8 69N2 69N4 69N5 69N6 72N6 72N8 74N6 79N8 82N1 82N2 82N5
8.200	-	8.300	(8)	48N3 69N3 72N7 87N2 90N1 90N2 90N3 95N3
8.300	-	8.400	(16)	8N4 19N4 28N1 35N1 36N5 41N4 50N2 53N5 54N4 87N3 91N1 91N2 92N1 92N2 92N3 95N2
8.400	-	8.500	(13)	0 0 0 0 0 0 10N4 14N5 34N4 89N1 89N2 89N3 91N3
8.500	-	8.600	(4)	0 0 0 29N5
8.600	-	8.700	(4)	0 0 0 0
8.700	-	8.800	(2)	0 0
8.800	-	8.900	(1)	37N3
8.900	-	9.000	(1)	0

POSPLTH VARIABLE NO. 16 PHYSICAL ANALYSIS POSITIVE PLATE THICKNESS AVERAGE (CM)
BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.729000E-01	.117500	.447000E-01	200	.870610E-01	.908494E-02

.7200E-01 -	.7600E-01	(25)	0 0 0 0 0 0 0 0 0 0 0 69N6 87N1 87N3 89N1 89N2 89N3 91N1 91N2 91N3 92N1 92N2 92N3 95N2 95N3
.7600E-01 -	.8000E-01	(28)	0 0 0 0 0 35N4 39N4 61N5 65N8 66N8 67N1 67N6 67N8 68N8 69N3 69N4 69N5 69N7 72N6 72N7 72N8 74N8 78N7 78N8 87N2 90N1 90N2 90N3
.8000E-01 -	.8400E-01	(30)	10N4 14N5 27N3 29N5 35N1 37N3 41N4 45N5 56N5 65N7 67N5 67N7 68N7 69N1 69N2 70N7 70N8 73N7 73N8 74N6 74N7 75N7 75N8 78N6 80N7 80N8 81N3 81N8 82N1 82N2
.8400E-01 -	.8800E-01	(26)	6N1 8N2 19N4 30N4 57N4 65N1 65N6 67N4 68N2 68N6 70N1 70N3 70N6 71N3 71N8 73N6 74N1 74N2 76N8 77N7 77N8 79N6 79N7 79N8 81N7 82N5
.8800E-01 -	.9200E-01	(27)	8N4 12N3 16N5 38N3 50N2 58N1 65N3 65N4 68N1 68N3 71N1 71N4 71N5 71N6 72N1 72N3 73N1 75N2 75N3 75N6 76N1 76N7 77N6 79N1 80N5 80N6 81N6
.9200E-01 -	.9600E-01	(28)	17N4 31N4 34N4 53N5 54N4 62N3 65N2 65N5 68N5 70N2 70N4 70N5 71N2 71N7 74N3 74N5 75N4 76N4 76N6 78N1 78N2 78N3 79N3 80N2 80N4 81N2 81N4 81N5
.9600E-01 -	.1000E+00	(21)	15N4 28N1 46N3 72N2 73N2 73N3 73N4 73N5 74N4 75N1 75N5 76N2 76N5 77N2 77N4 78N4 78N5 79N2 80N1 80N3 81N1
.1000E+00 -	.1040	(10)	4N4 23N5 36N5 40N3 48N3 68N4 76N3 77N5 79N4 79N5
.1040 -	.1080	(2)	72N5 77N1
.1080 -	.1120	(2)	72N4 77N3
.1120 -	.1160	(0)	
.1160 -	.1200	(1)	63N4

NEGPLTH

VARIABLE NO. 17 PHYSICAL ANALYSIS NEGATIVE PLATE THICKNESS AVERAGE (CM) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.799000E-01	.101300	.214000E-01	200	.847365E-01	.294378E-02

.7800E-01 -	.8000E-01	(1)	40N3
.8000E-01 -	.8200E-01	(23)	0 0 15N4 16N5 23N5 30N4 37N3 38N3 54N4 65N1 66N8 69N5 69N7 71N3 74N2 75N3 76N1 79N1 81N3 87N2 87N3 92N2 95N2
.8200E-01 -	.8400E-01	(70)	0 0 0 0 0 0 0 0 0 8N2 8N4 12N3 17N4 19N4 27N3 31N4 34N4 35N4 39N4 41N4 45N5 46N3 48N3 50N2 53N5 56N5 57N4 58N1 61N5 62N3 65N2 65N5 65N8 67N4 67N5 68N5 68N7 68N8 69N2 69N3 69N4 69N6 72N4 72N5 72N7 72N8 73N1 73N2 73N7 74N1 75N2 75N7 76N2 76N4 76N8 78N1 78N2 78N3 78N6 79N3 80N1 80N5 80N8 87N1 90N1 90N3 91N1 92N1 92N3 95N3
.8400E-01 -	.8600E-01	(55)	0 0 0 0 6N1 14N5 28N1 29N5 63N4 65N3 65N4 65N6 67N1 67N8 68N1 68N3 68N4 69N1 70N1 70N2 71N2 72N2 72N3 72N6 73N3 73N4 74N3 74N5 74N7 75N1 75N4 75N6 76N3 76N6 77N2 77N4 77N8 78N4 78N5 79N2 79N6 79N7 79N8 80N2 81N1 81N4 81N6 81N7 82N5 89N1 89N2 89N3 90N2 91N2 91N3
.8600E-01 -	.8800E-01	(31)	0 4N4 10N4 36N5 65N7 68N6 70N3 71N1 71N5 71N7 73N5 73N8 74N4 74N6 74N8 75N5 76N5 76N7 77N5 77N6 77N7 78N7 78N8 79N4 79N5 80N3 80N4 81N5 81N8 82N1 82N2
.8800E-01 -	.9000E-01	(11)	67N6 67N7 68N2 71N8 72N1 73N6 75N8 77N1 77N3 80N6 81N2
.9000E-01 -	.9200E-01	(2)	71N6 80N7
.9200E-01 -	.9400E-01	(3)	70N6 70N7 71N4
.9400E-01 -	.9600E-01	(3)	35N1 70N4 70N5
.9600E-01 -	.9800E-01	(0)	
.9800E-01 -	.1000E+00	(0)	
.1000E+00 -	.1020	(1)	70N8

TOTALNEG

VARIABLE NO. 18 CHEMICAL ANALYSIS TOTAL CAPACITY NEGATIVE CELL (AH) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
10.7000	19.7000	9.00000	191	16.4539	1.23223

10.40	-	11.20	(1)	74N2
11.20	-	12.00	(0)	
12.00	-	12.80	(0)	
12.80	-	13.60	(2)	57N4 71N2
13.60	-	14.40	(6)	16N5 69N4 71N1 72N1 77N5 78N1
14.40	-	15.20	(17)	6N1 8N2 12N3 31N4 35N4 40N3 56N5 67N4 70N5 71N3 71N5 71N6 71N7 72N4 73N2 73N5 87N1
15.20	-	16.00	(30)	4N4 15N4 17N4 27N3 39N4 45N5 46N3 61N5 62N3 67N5 68N6 68N7 70N1 70N2 70N4 71N4 72N5 73N3 73N4 74N4 74N5 75N1 75N5 76N1 76N4 76N6 78N5 79N7 80N4 80N5
16.00	-	16.40	(51)	8N4 19N4 23N5 28N1 36N5 48N3 58N1 65N1 65N2 65N3 65N4 65N5 65N7 67N1 68N1 68N2 68N4 68N5 69N1 70N6 72N2 72N3 72N5 73N1 73N6 74N3 75N2 75N4 75N7 76N2 76N3 76N5 77N3 77N4 77N6 77N7 77N8 78N2 78N3 78N4 79N1 79N2 79N3 79N5 80N1 80N3 80N6 81N1 81N4 81N6 81N7
16.80	-	17.60	(56)	10N4 30N4 34N4 35N1 38N3 41N4 50N2 54N4 63N4 65N6 65N8 66N8 67N6 67N7 67N8 68N3 68N8 69N2 69N5 69N6 69N7 70N3 70N7 71N8 72N7 73N7 73N8 74N6 74N7 75N3 75N6 76N7 76N8 77N1 77N2 78N6 79N4 79N6 79N8 80N7 80N8 81N2 81N3 81N5 81N8 82N1 82N2 82N5 87N2 89N3 90N1 90N2 90N3 92N2 95N2 95N3
17.60	-	18.40	(17)	0 0 0 0 0 0 0 69N3 70N8 72N6 74N1 74N8 78N7 78N8 91N1 91N2 92N3
18.40	-	19.20	(9)	0 0 0 0 0 89N1 89N2 91N3 92N1
19.20	-	20.00	(2)	0 80N2

TOTALPOS

VARIABLE NO. 19 CHEMICAL ANALYSIS TOTAL CAPACITY POSITIVE CELL (AH) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
7.40000	12.1000	4.70000	151	10.0318	.718087

7.200	-	7.600	(2)	67N8 77N5
7.600	-	8.000	(0)	
8.000	-	8.400	(2)	0 0
8.400	-	8.800	(2)	70N6 74N8
8.800	-	9.200	(7)	0 0 65N8 72N7 78N8 87N2 91N1
9.200	-	9.600	(21)	0 0 69N4 69N5 69N6 70N8 72N6 72N8 74N2 74N4 78N7 79N6 80N5 87N1 87N3 89N1 90N1 90N2 92N2 92N3 95N2
9.600	-	10.00	(36)	0 0 65N1 65N2 65N6 65N7 67N1 67N4 67N5 68N8 69N2 69N3 70N5 70N7 71N8 74N6 74N7 75N5 75N8 76N1 76N8 77N3 78N1 78N6 80N1 80N2 80N6 80N7 81N3 81N6 81N7 81N8 82N2 82N5 92N1 95N3
10.00	-	10.40	(30)	0 10N4 66N8 67N6 67N7 68N3 68N4 69N1 70N1 70N4 71N2 71N6 72N1 72N3 73N1 73N8 74N5 75N4 75N7 76N4 77N2 77N4 78N4 79N7 79N8 80N3 80N4 80N8 81N2 82N1
10.40	-	10.80	(29)	0 0 35N1 68N1 68N6 68N7 69N7 70N2 71N1 71N3 71N4 71N5 72N2 73N2 73N6 73N7 74N1 74N3 75N2 75N3 76N6 77N1 77N4 77N7 77N8 78N2 79N2 79N3 90N3
10.80	-	11.20	(15)	0 0 14N5 29N5 68N2 71N7 72N4 72N5 73N5 75N6 76N3 76N7 78N3 79N1 79N5
11.20	-	11.60	(5)	68N5 75N1 76N2 76N5 78N5
11.60	-	12.00	(1)	73N4
12.00	-	12.40	(1)	73N3

WDIFF

VARIABLE NO. 20 ELECTROLYTE ANALYSIS CORE WET WEIGHT MINUS DRY WEIGHT (G)
BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
19.1000	48.3000	29.2000	132	25.9682	3.87823

18.00 - 20.00	(3)	75N8 79N5 79N8		
20.00 - 22.00	(7)	0 0 0 37N3 54N4 74N7 79N4		
22.00 - 24.00	(24)	0 0 0 28N1 41N4 50N2 53N5 65N2 65N4 68N7 68N8 73N4 74N6 75N3 75N4 75N5 75N6 75N7 78N6 79N6 79N7 91N1 91N2 91N3		
24.00 - 26.00	(41)	0 0 6N1 8N2 8N4 10N4 14N5 17N4 19N4 27N3 29N5 36N5 45N5 48N3 61N5 62N3 65N1 65N3 65N5 65N7 65N8 67N6 67N7 67N8 69N2 71N8 73N7 74N8 75N2 76N8 77N6 77N7 77N8 78N3 81N1 82N1 82N2 82N5 90N1 90N2 90N3		
26.00 - 28.00	(34)	12N3 30N4 58N1 63N4 67N1 67N4 67N5 68N6 69N1 70N1 71N1 71N3 71N4 71N7 72N4 72N5 73N1 73N2 73N3 73N5 73N6 73N8 74N1 74N2 74N4 74N5 76N2 76N3 76N5 76N6 76N7 78N1 78N5 81N2		
28.00 - 30.00	(12)	16N5 31N4 35N1 46N3 56N5 70N2 71N2 71N5 71N6 74N3 76N1 80N1		
30.00 - 32.00	(6)	38N3 40N3 57N4 75N1 78N2 80N2		
32.00 - 34.00	(2)	4N4 23N5		
34.00 - 36.00	(0)			
36.00 - 38.00	(0)			
38.00 - 40.00	(1)	78N8		
40.00 - 42.00	(0)			
42.00 - 44.00	(0)			
44.00 - 46.00	(0)			
46.00 - 48.00	(1)	80N4		
48.00 - 50.00	(1)	70N6		

CELL KOH

VARIABLE NO. 21 ELECTROLYTE ANALYSIS CELL EXTRACT KOH (G)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
-.180000	10.1200	10.3000	192	4.17491	1.62365

-1.000	-	0.	(1)	79N6
0.	-	1.000	(1)	0
1.000	-	2.000	(14)	8N2 17N4 30N4 34N4 50N2 54N4 61N5 63N4 65N8 68N3 72N3 74N3 75N5 79N7
2.000	-	3.000	(23)	0 6N1 8N4 16N5 19N4 27N3 46N3 53N5 56N5 57N4 67N4 67N5 75N1 75N2 75N3 75N4 75N6 75N7 75N8 76N4 79N2 79N3 79N4
3.000	-	4.000	(48)	4N4 12N3 23N5 36N5 37N3 38N3 39N4 40N3 65N1 67N1 67N6 69N1 69N2 69N3 70N1 70N2 71N1 71N2 71N3 71N4 71N5 71N7 73N1 73N2 73N4 73N5 73N7 73N8 74N1 74N2 74N4 74N5 74N8 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 79N5 79N8 80N1 81N1 81N2 81N3
4.000	-	5.000	(57)	0 0 0 0 0 14N5 15N4 31N4 45N5 48N3 58N1 65N2 65N4 65N5 65N7 66N8 67N7 67N8 68N1 68N2 68N5 68N6 68N7 68N8 70N4 70N5 70N6 70N7 71N6 71N8 72N1 72N2 72N4 72N5 72N6 73N3 73N6 74N6 74N7 77N1 77N2 77N3 77N4 78N6 78N7 78N8 79N1 80N3 80N4 80N8 81N6 81N7 82N1 82N2 82N5 95N2 95N3
5.000	-	6.000	(22)	0 0 0 0 0 28N1 29N5 41N4 65N3 69N6 69N7 70N8 72N7 72N8 80N2 80N6 80N7 87N1 87N3 91N1 91N2 91N3
6.000	-	7.000	(14)	0 10N4 35N1 35N4 62N3 68N4 76N1 76N5 76N7 76N8 80N5 87N2 92N1 92N3
7.000	-	8.000	(9)	0 69N4 69N5 76N2 76N3 76N6 90N2 90N3 92N2
8.000	-	9.000	(2)	0 90N1
9.000	-	10.00	(0)	
10.00	-	11.00	(1)	0

CELLK2CO

VARIABLE NO. 22 ELECTROLYTE ANALYSIS CELL EXTRACT K2CO3 (0)
BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.31000	10.4400	9.13000	192	4.16109	1.37258

.9000	- 1.800	(5)	0 0 50N2 54N4 87N2	
1.800	- 2.700	(21)	0 0 0 0 0 0 10N4 14N5 17N4 30N4 56N5 63N4 72N7 80N5 87N1 87N3 90N1 90N2 91N1 91N2 92N2	
2.700	- 3.600	(38)	0 0 0 0 0 0 0 0 35N1 36N5 37N3 39N4 45N5 58N1 62N3 65N5 65N7 68N4 69N6 70N7 70N8 72N5 72N8 73N3 75N1 75N4 75N5 76N3 78N7 78N8 80N6 82N1 82N2 90N3 91N3 92N1 92N3 95N3	
3.600	- 4.500	(57)	15N4 19N4 28N1 29N5 31N4 35N4 41N4 48N3 65N2 65N3 65N4 66N8 67N6 67N8 68N1 68N2 68N5 68N6 68N7 68N8 69N2 69N3 69N4 69N5 69N7 70N4 70N5 70N6 71N8 73N2 73N6 73N7 74N7 74N8 75N2 75N3 75N6 75N7 75N8 76N2 76N3 76N5 76N7 76N8 77N2 77N4 78N1 78N5 78N6 80N2 80N4 80N7 80N8 81N6 81N7 82N5 95N2	
4.500	- 5.400	(42)	6N1 8N2 8N4 27N3 34N4 53N5 61N5 65N1 67N1 67N7 69N1 70N1 70N2 71N2 71N6 71N7 72N1 72N2 72N4 72N5 73N1 73N8 74N1 74N6 76N1 77N1 77N3 77N5 77N6 77N7 77N8 78N2 78N3 78N4 79N2 79N3 79N4 79N5 79N8 80N3 81N1 81N3	
5.400	- 6.300	(18)	12N3 16N5 67N4 67N5 68N3 71N1 71N3 71N4 71N5 72N3 73N4 73N5 74N2 74N4 74N5 79N1 80N1 81N2	
6.300	- 7.200	(4)	46N3 57N4 74N3 79N6	
7.200	- 8.100	(5)	4N4 23N5 38N3 40N3 79N7	
8.100	- 9.000	(1)	65N8	
9.000	- 9.900	(0)		
9.900	- 10.80	(1)	76N4	

CELCONC

VARIABLE NO. 23 ELECTROLYTE ANALYSIS CELL EXTRACT KOH CONCENTRATION PERCENT WEIGHT
BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
-.760000	45.5800	46.3400	132	13.2526	6.84097

-4.000	-	0.	(1)	79N6
0.	-	4.000	(1)	0
4.000	-	8.000	(10)	8N2 16N5 17N4 30N4 50N2 54N4 61N5 63N4 74N3 79N7
8.000	-	12.00	(39)	4N4 6N1 8N4 12N3 19N4 23N5 27N3 38N3 40N3 46N3 53N5 56N5 57N4 65N8 67N1 67N4 67N5 70N1 70N6 71N1 71N2 71N3 71N5 74N2 74N4 74N5 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 78N2 78N8 79N4 80N1 80N4
12.00	-	16.00	(29)	36N5 65N1 67N6 67N7 69N1 69N2 70N2 71N4 71N6 71N7 72N4 72N5 73N1 73N2 73N4 73N5 73N6 73N7 73N8 74N1 74N8 77N6 77N7 77N8 78N1 78N3 78N5 81N1 81N2
16.00	-	20.00	(24)	14N5 31N4 37N3 45N5 48N3 58N1 65N2 65N3 65N4 65N5 65N7 67N8 68N6 68N7 68N8 71N8 73N3 74N6 78N6 79N5 79N8 80N2 82N1 82N2
20.00	-	24.00	(12)	0 0 0 28N1 29N5 35N1 41N4 74N7 76N1 82N5 91N2 91N3
24.00	-	28.00	(12)	0 0 0 10N4 62N3 76N2 76N3 76N5 76N6 76N7 76N8 91N1
28.00	-	32.00	(3)	90N1 90N2 90N3
32.00	-	36.00	(0)	
36.00	-	40.00	(0)	
40.00	-	44.00	(0)	
44.00	-	48.00	(1)	0

CELAMT

VARIABLE NO. 24 ELECTROLYTE ANALYSIS CELL EXTRACT KOH AMOUNT (CC)
BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
15.3200	37.5900	22.2700	114	20.1881	2.98530

14.00 - 16.00	(3)	54N4 79N5 79N8		
16.00 - 18.00	(12)	0 0 0 0 0	50N2 73N4 74N7 75N8 79N4 79N7 91N1	
18.00 - 20.00	(43)	0 0 0	10N4 29N5 36N5 48N3 53N5 65N1 65N2 65N3 65N4 65N5 65N7 65N8 67N6 67N8 68N7 68N8 69N2	
		73N7 74N6 74N8	75N3 75N4 75N5 75N6 75N7 76N8 77N6 77N8 78N3 78N6 79N6 81N1 82N1 82N2 82N5 90N1 90N2	
		90N3 91N2 91N3		
20.00 - 22.00	(44)	4N4 14N5 19N4	27N3 30N4 35N1 45N5 56N5 58N1 67N1 67N4 67N5 67N7 68N6 69N1 70N1 71N1 71N3 71N4 71N6	
		71N7 71N8 72N4	72N5 73N1 73N2 73N3 73N6 73N8 74N1 74N2 74N4 74N5 75N2 76N1 76N2 76N3 76N5 76N6 76N7	
		77N7 78N1 78N5	81N2	
22.00 - 24.00	(8)	16N5 70N2 71N2	71N5 74N3 78N2 80N1 80N2	
24.00 - 26.00	(0)			
26.00 - 28.00	(1)	75N1		
28.00 - 30.00	(1)	78N2		
30.00 - 32.00	(0)			
32.00 - 34.00	(0)			
34.00 - 36.00	(0)			
36.00 - 38.00	(2)	70N6 80N4		

EOCTEST1

VARIABLE NO. 25 MANUFACTURERS TESTS NO1 EOC VOLTAGE (CHG C/2 150MIN 22 DEGREES C) BY PACK*CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.43600	1.50200	.660000E-01	445	1.45835	.105520E-01

1.434	-	1.440	(1)	65N8
1.440	-	1.446	(49)	2N1 2N2 5N2 9N4 10N1 10N3 10N4 10N5 12N2 13N5 15N1 18N1 20N1 20N2 23N1 23N2 26N2 28N3 28N5 29N2 31N3 31N5 35N2 41N1 41N2 43N1 43N3 43N5 46N1 47N1 48N3 48N4 48N5 49N2 51N2 54N2 54N4 56N2 57N3 57N5 59N1 59N2 62N3 62N4 62N5 64N1 64N3 64N4 67N3
1.446	-	1.452	(75)	2N3 2N4 2N5 4N1 4N3 5N1 5N3 5N4 5N5 7N3 7N4 9N1 9N3 9N5 12N1 13N3 14N1 18N2 18N3 18N4 20N3 20N4 20N5 21N1 21N2 21N3 21N4 21N5 23N3 23N4 23N5 25N2 27N2 28N4 31N4 32N1 32N2 35N1 35N3 35N4 35N5 36N2 38N1 40N1 40N2 40N3 40N4 40N5 43N4 44N1 44N2 45N1 46N4 47N2 48N2 49N1 49N3 49N4 49N5 51N1 52N5 54N1 54N3 54N5 57N4 58N1 61N1 61N2 61N3 64N2 64N5 66N8 78N8 81N2 83N7
1.452	-	1.458	(131)	4N2 6N5 7N1 7N2 8N4 8N5 9N2 10N2 11N1 11N2 11N3 11N4 11N5 12N4 13N1 13N2 13N4 14N2 14N3 14N4 14N5 15N2 16N1 16N2 16N3 16N4 16N5 18N5 19N3 25N1 25N3 27N1 27N3 27N4 27N5 28N2 29N1 30N1 30N2 30N3 31N1 31N2 32N3 32N4 32N5 33N1 33N2 34N3 34N4 34N5 36N3 37N3 37N4 37N5 38N2 42N1 42N2 43N2 44N3 44N4 44N5 45N2 45N2 46N5 47N3 47N4 47N5 48N1 52N1 52N4 55N3 55N4 55N5 56N1 56N4 57N2 58N2 58N3 58N4 58N5 59N3 60N1 60N2 61N4 61N5 62N1 62N2 63N1 63N2 65N1 65N3 66N1 66N2 68N1 68N4 68N5 69N5 69N6 70N1 70N2 70N3 70N5 71N1 71N2 71N3 71N4 71N5 71N8 72N1 72N2 73N2 73N3 76N3 76N4 76N6 77N3 78N1 78N2 78N6 78N7 83N6 83N8 84N5 84N8 85N1 85N5 85N7 85N8 86N3 86N4 86N5
1.458	-	1.464	(124)	1N1 1N2 1N3 1N4 1N5 3N1 3N2 4N4 6N1 6N3 6N4 7N5 8N3 12N3 17N1 17N2 17N4 17N5 19N1 19N2 19N4 19N5 22N1 22N3 22N5 24N1 24N2 24N3 24N4 24N5 25N4 25N5 26N1 28N1 29N4 30N4 30N5 33N3 33N5 34N1 36N4 36N5 37N1 37N2 38N4 38N5 39N1 39N2 39N4 39N5 41N3 41N4 42N3 42N4 42N5 45N3 45N4 45N5 50N1 50N2 50N3 50N4 50N5 51N4 51N5 52N1 53N2 53N4 55N1 55N2 56N3 56N5 57N1 59N4 60N3 60N4 60N5 63N3 63N4 63N5 65N2 65N4 65N5 65N7 66N7 67N5 67N6 68N2 68N3 68N6 68N8 69N3 69N4 70N4 70N7 71N6 71N7 72N3 72N4 72N6 73N1 73N6 74N1 74N3 76N5 77N4 77N7 77N8 82N1 82N2 82N5 83N1 83N4 83N5 84N3 84N4 84N6 84N7 85N2 85N3 85N4 85N6 86N1 86N6
1.464	-	1.470	(53)	3N3 3N4 3N5 6N2 8N1 8N2 12N5 15N4 15N5 17N3 22N2 22N4 26N3 26N4 26N5 29N3 29N5 33N4 34N2 38N3 39N3 46N3 51N3 52N2 53N1 53N5 59N5 66N3 66N6 67N4 67N7 67N8 68N7 69N8 70N6 72N5 76N2 76N7 76N8 77N1 77N2 77N5 77N6 79N1 79N6 80N2 80N3 80N4 81N1 82N3 82N4 86N2 86N7
1.470	-	1.476	(20)	4N5 15N3 36N1 53N3 67N2 69N1 69N7 70N5 73N5 74N2 75N4 79N2 79N4 80N6 80N7 81N4 81N5 81N6 87N2 87N3
1.476	-	1.482	(23)	66N5 72N7 72N8 73N8 74N4 74N5 74N7 74N8 75N1 75N2 75N3 75N5 75N7 76N1 78N4 79N3 79N5 80N1 80N5 80N8 84N1 84N2 86N8
1.482	-	1.488	(10)	41N5 67N1 69N2 75N6 75N8 79N7 81N7 81N8 83N3 87N1
1.488	-	1.494	(5)	65N6 66N4 73N4 74N6 79N8
1.494	-	1.500	(2)	73N7 78N3
1.500	-	1.506	(2)	78N5 83N2

EOCTEST2

MANUFACTURERS TESTS NO2 EOC VOLTAGE (CHG C/2 150MIN 22 DEGREES C)

VARIABLE NO. 26 BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.45000	1.55200	.102000	495	1.47294	.136202E-01

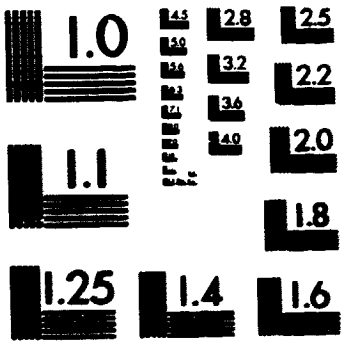
1.450	-	1.460	(56)	2N1 2N2 2N3 2N4 2N5 5N1 5N2 5N3 5N4 9N4 12N1 20N1 20N2 20N3 20N4 20N5 21N3 21N5 23N1 23N2 23N3 23N4 23N5 28N3 29N2 35N2 35N3 35N4 35N5 40N1 40N2 40N3 40N4 40N5 44N2 46N1 46N4 47N2 49N2 49N3 49N4 49N5 52N5 54N1 54N2 54N3 54N4 54N3 56N2 57N5 58N1 59N1 59N2 61N2 64N1 64N4
1.460	-	1.470	(192)	1N2 1N5 3N1 3N2 3N3 3N4 3N5 4N1 4N2 4N3 4N4 5N5 6N1 6N5 7N1 7N2 7N3 7N4 8N1 8N2 8N3 9N2 9N3 9N5 10N1 10N2 10N3 10N5 11N1 11N2 11N3 11N4 11N5 12N2 13N1 13N2 13N3 13N5 14N1 14N3 14N4 14N5 15N1 15N2 16N1 16N2 16N3 16N4 16N5 17N3 17N4 17N5 18N1 18N2 18N3 18N4 18N5 19N1 19N2 19N3 21N1 21N2 21N4 22N3 22N5 24N1 24N2 24N4 24N5 25N1 25N2 25N3 25N4 26N2 27N1 27N2 27N3 27N4 27N5 28N4 28N5 29N1 30N1 30N2 30N3 31N1 31N3 31N5 32N1 32N2 32N3 32N4 32N5 33N1 33N2 34N2 34N3 34N4 34N5 35N1 35N2 36N3 37N1 37N2 37N3 37N4 37N5 38N1 39N2 39N4 41N1 41N2 42N1 42N2 42N4 42N5 43N2 43N3 43N5 44N1 44N3 44N4 44N5 45N1 45N2 46N2 46N5 47N1 47N3 47N4 47N5 48N1 48N2 48N3 48N4 48N5 49N1 50N1 50N5 51N2 52N1 52N2 52N3 52N4 55N1 55N2 55N3 55N4 55N5 56N4 57N2 57N3 57N4 58N2 58N3 58N4 58N5 59N3 60N1 60N2 61N1 61N3 61N4 61N5 62N1 62N3 62N4 62N5 63N1 63N3 63N4 64N2 64N3 64N5 83N1 83N2 83N3 83N5 83N6 83N7 84N1 84N2 84N3 84N4 84N5 85N1 86N2 86N3 86N4 86N5 86N6 86N7
1.470	-	1.480	(136)	1N1 1N3 1N4 6N2 6N3 6N4 7N5 8N3 8N4 9N1 10N4 12N3 12N4 13N4 14N2 17N1 17N2 19N4 19N5 22N1 22N2 22N4 24N3 25N5 26N1 28N2 29N4 30N4 30N5 31N2 31N4 33N3 33N4 33N5 34N1 36N4 36N5 38N2 38N3 38N4 38N5 39N1 39N4 39N5 41N3 41N4 42N3 43N1 43N4 45N3 45N4 45N5 50N2 50N3 50N4 51N1 51N3 51N4 51N5 53N1 53N2 53N4 55N1 56N3 56N5 57N1 59N4 60N3 60N4 60N5 62N2 63N2 63N5 65N1 65N2 65N3 66N1 66N2 66N8 68N1 68N4 68N5 68N6 68N8 69N5 69N8 70N1 70N2 70N8 71N2 71N3 71N4 71N5 71N6 71N7 71N8 72N1 72N4 73N1 73N2 73N3 73N5 74N1 74N3 76N3 76N4 76N5 76N6 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N6 78N7 78N8 80N3 80N4 80N7 81N2 83N4 83N8 84N6 84N7 84N8 85N2 85N3 85N4 85N5 85N6 85N7 85N8 86N1 86N8
1.480	-	1.490	(59)	4N5 12N5 15N4 15N5 26N3 26N4 26N5 28N1 29N3 29N5 36N1 46N3 53N3 53N5 59N5 65N4 65N7 65N8 66N6 67N3 68N2 68N3 68N7 69N2 69N3 69N4 70N3 70N4 70N6 70N7 71N1 72N2 72N3 72N5 72N6 73N5 74N2 75N1 75N2 75N3 75N4 75N5 75N7 76N2 76N7 77N1 78N1 78N2 79N1 79N2 80N1 80N2 80N5 80N6 81N1 82N1 82N4 82N5 87N3
1.490	-	1.500	(28)	15N3 55N5 66N3 66N7 67N2 67N4 67N5 67N6 67N7 67N8 69N1 69N6 69N7 72N8 74N4 74N5 74N8 75N6 75N8 76N8 79N3 79N4 79N5 79N7 79N8 82N2 82N3 87N2
1.500	-	1.510	(12)	67N1 70N5 72N7 73N8 74N6 76N1 78N4 79N6 80N8 81N4 81N7 87N1
1.510	-	1.520	(7)	41N5 65N6 66N4 66N5 73N7 78N3 81N5
1.520	-	1.530	(2)	81N6 81N8
1.530	-	1.540	(2)	74N7 78N5
1.540	-	1.550	(0)	
1.550	-	1.560	(1)	73N4

EOCTEST3

VARIABLE NO. 27 MANUFACTURERS TESTS NO3 EOC VOLTAGE (CHG C/8 12 HR 22 DEGREES C) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.42700	1.47600	.490000E-01	492	1.44197	.550938E-02

1.424	-	1.428	(1)	83N4
1.428	-	1.432	(5)	23N2 83N6 83N7 84N2 85N3
1.432	-	1.436	(44)	2N2 2N4 4N3 4N4 5N1 12N1 20N2 20N3 20N5 21N2 21N3 21N4 21N5 23N1 23N3 23N5 29N2 35N1 38N1 40N1 46N1 49N2 54N1 54N2 54N4 57N5 59N1 64N1 64N2 64N4 83N5 83N8 84N4 84N5 84N6 84N7 84N8 85N4 85N5 85N6 85N7 85N8 86N3 86N4
1.436	-	1.440	(129)	1N1 2N1 2N3 2N5 4N1 4N2 5N2 5N3 5N4 7N1 7N2 7N3 7N4 7N5 9N3 9N4 9N5 10N1 12N2 13N2 13N5 15N1 15N2 18N1 18N2 18N3 18N4 18N5 19N1 19N2 20N1 20N4 21N1 23N4 24N1 24N2 26N1 26N2 28N1 28N2 28N3 28N5 29N1 31N1 31N3 31N5 32N2 35N2 35N3 35N4 35N5 36N2 36N3 37N5 38N2 38N4 40N2 40N3 40N4 40N5 41N1 41N2 43N1 43N2 43N3 43N5 44N1 44N2 46N2 46N4 46N5 47N2 48N2 48N3 48N4 48N5 49N1 49N3 49N4 49N5 51N1 51N2 52N5 54N3 54N5 56N1 56N2 56N4 57N3 57N4 59N2 59N3 61N2 61N3 62N2 62N3 62N4 62N5 63N3 63N4 64N3 64N5 68N5 69N4 69N5 71N6 71N8 72N4 73N2 76N1 76N3 76N5 76N6 76N7 77N2 77N3 77N7 83N1 83N2 83N3 84N1 84N3 85N1 86N1 86N2 86N5 86N6 86N7 87N3
1.440	-	1.444	(123)	1N2 5N5 6N1 6N2 6N5 8N1 8N2 8N5 10N2 10N3 10N4 10N5 13N1 13N3 13N4 14N3 14N4 14N5 17N3 17N4 17N5 22N5 24N4 25N4 25N5 26N3 27N2 27N3 27N4 27N5 28N4 30N3 30N4 30N5 31N2 31N4 32N1 32N3 32N4 33N1 33N2 33N3 33N4 33N5 36N4 36N5 37N3 37N4 38N3 38N5 39N1 39N2 39N4 42N3 42N4 42N5 44N3 44N4 44N5 45N3 45N4 45N5 47N3 48N1 51N3 51N4 51N5 52N3 53N1 53N2 55N1 56N3 56N5 57N1 57N2 58N1 58N2 58N3 58N5 59N4 59N5 60N3 60N5 61N4 61N5 62N1 63N5 65N3 66N1 66N8 67N8 68N1 68N4 68N6 68N8 69N6 69N7 69N8 70N5 70N6 70N7 71N4 71N5 71N7 72N3 73N1 74N2 74N3 76N2 76N4 76N8 77N1 77N5 77N6 77N8 78N1 78N3 78N6 78N7 78N8 81N2 85N2 86N8
1.444	-	1.448	(113)	1N4 1N5 3N1 3N2 3N3 3N4 3N5 4N5 6N3 6N4 8N3 9N1 9N2 11N1 11N2 11N4 11N5 12N3 12N4 12N5 14N1 14N2 15N3 15N4 15N5 16N1 17N1 17N2 19N3 19N4 19N5 22N2 24N5 25N1 25N2 26N4 27N1 29N3 29N4 29N5 30N1 30N2 32N5 34N1 34N2 34N3 34N4 34N5 36N1 37N1 37N2 41N3 41N4 41N5 42N1 42N2 43N4 45N1 45N2 46N3 47N1 47N4 47N5 50N1 50N2 50N3 50N5 52N1 52N4 55N2 55N3 55N4 58N4 60N1 60N2 60N4 61N1 63N1 63N2 65N1 65N2 65N5 65N6 65N8 66N2 66N6 67N1 67N2 67N3 67N4 67N7 68N7 70N2 70N4 70N8 71N2 72N1 72N2 72N5 72N6 73N3 73N4 73N5 73N6 74N1 78N2 79N7 80N2 80N3 80N7 81N1 81N8 87N1
1.448	-	1.452	(58)	1N3 4N4 11N3 16N2 16N3 22N1 22N3 22N4 24N3 26N5 39N3 39N5 50N4 52N2 53N4 53N5 55N5 65N4 66N3 66N4 66N5 66N7 67N5 67N6 68N2 69N2 69N3 70N1 70N3 71N1 71N3 72N7 73N7 75N1 75N2 75N3 75N4 75N5 75N7 75N8 78N4 78N5 79N1 79N2 79N3 79N4 79N5 79N6 79N8 80N4 80N5 80N6 80N8 82N1 82N3 82N4 82N5 87N2
1.452	-	1.456	(14)	53N3 65N7 68N3 69N1 72N8 74N4 74N5 74N7 74N8 75N6 77N4 80N1 81N4 81N5
1.456	-	1.460	(2)	74N6 81N6
1.460	-	1.464	(1)	82N2
1.464	-	1.468	(0)	
1.468	-	1.472	(1)	73N8
1.472	-	1.476	(0)	
1.476	-	1.480	(1)	81N7



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

EOCTEST4

MANUFACTURERS TESTS NO4 EOC VOLTAGE (CHG C/10 48 HR 22 DEGREES C)

VARIABLE NO. 28 BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.42700	1.47600	.490000F-01	491	1.44124	.637999E-02

1.424	-	1.428	(2)	57N3 62N4
1.428	-	1.432	(20)	2N1 2N2 10N1 20N2 21N5 23N1 23N2 28N1 28N2 28N3 43N1 43N2 48N5 49N1 49N2 57N4 57N5 62N2 62N3 62N5
1.432	-	1.436	(53)	5N1 5N2 5N3 5N5 10N2 10N3 10N5 13N2 13N3 13N5 18N1 18N2 18N3 18N4 18N5 20N1 20[illegible] [illegible]0N4 20N5 21N2 21N3 21N4 23N3 23N4 23N5 28N4 28N5 31N1 31N2 31N3 31N5 35N1 35N2 35N5 43N4 43N5 4[illegible] [illegible]N3 48N4 49N3 49N4 49N5 54N1 54N2 54N5 56N1 56N2 76N1 76N2 76N3 76N4 76N5 76N6
1.436	-	1.440	(143)	1N2 2N3 2N4 2N5 5N4 6N1 6N5 9N4 9N5 10N4 12N1 12N2 12N3 12N4 12N5 13N1 13N4 15N1 15N2 15N4 19N2 19N3 21N1 24N2 24N4 25N5 26N1 26N2 26N3 26N4 26N5 29N1 29N2 29N4 29N5 30N3 31N4 35N3 35N4 39N2 39N4 40N3 40N4 40N5 41N2 41N3 41N4 42N4 42N5 43N3 44N1 44N2 45N3 45N4 45N5 46N1 46N2 46N3 46N5 47N2 48N1 50N3 50N4 50N5 53N5 54N3 54N4 57N1 58N1 59N1 59N2 59N3 59N5 60N3 60N5 61N2 62N1 63N3 63N4 63N5 64N1 64N2 64N3 64N4 64N5 65N1 65N2 65N3 66N1 66N4 66N5 66N6 66N7 66N8 67N4 67N8 68N1 68N5 68N7 68N8 69N4 69N6 70N6 71N4 71N6 71N7 72N4 73N1 73N6 74N3 76N7 76N8 81N2 82N4 82N5 83N1 83N2 83N4 83N5 83N6 83N7 84N1 84N3 84N4 84N5 84N6 84N7 84N8 85N1 85N4 85N5 85N6 85N7 85N8 86N1 86N2 86N3 86N4 86N5 86N6 86N7 86N8 87N3
1.440	-	1.444	(119)	1N1 1N3 1N4 6N2 6N3 6N4 9N3 11N2 11N4 11N5 14N3 14N4 14N5 15N3 15N5 19N1 19N4 19N5 24N1 24N5 25N1 25N2 25N4 27N1 27N2 27N3 27N4 27N5 29N3 30N4 30N5 32N1 32N2 32N3 32N4 39N1 39N5 41N5 42N2 42N3 44N3 44N4 44N5 45N1 45N2 46N4 47N1 47N3 50N1 50N2 53N1 53N2 53N4 56N4 57N2 58N2 58N4 58N5 59N4 60N4 61N1 61N3 61N4 61N5 65N4 65N5 65N6 65N8 66N2 66N3 67N1 67N2 67N3 67N6 67N7 68N2 68N3 68N4 68N6 69N1 69N5 69N7 69N8 70N1 70N2 70N4 70N5 70N7 71N2 71N3 71N5 71N8 72N1 72N2 72N3 72N5 72N6 72N7 73N3 74N1 78N4 78N5 78N6 78N7 78N8 79N7 80N3 81N1 81N7 81N8 82N1 82N2 82N3 83N3 83N8 84N2 85N2 87N1 87N2
1.444	-	1.448	(78)	3N1 3N2 3N4 3N5 8N1 8N2 8N5 9N1 9N2 11N1 11N3 14N1 14N2 16N1 16N2 16N3 16N4 16N5 17N1 17N3 17N4 17N5 22N2 24N3 25N3 30N1 30N2 32N5 33N1 33N2 34N2 37N1 37N2 37N3 37N4 37N5 39N3 41N1 42N1 47N4 47N5 52N1 52N3 52N5 53N3 55N1 55N2 55N4 56N5 58N3 60N1 60N2 63N1 63N2 67N5 69N2 69N3 70N3 71N1 73N2 74N6 74N7 74N8 77N2 77N3 77N4 77N5 77N6 77N7 78N1 79N5 80N1 80N2 80N4 80N5 80N6 80N7 85N3
1.448	-	1.452	(44)	1N5 3N3 4N3 7N1 7N2 7N3 8N3 8N4 17N2 22N1 22N3 22N4 22N5 33N3 33N5 34N1 34N3 34N4 34N5 36N2 38N1 38N4 52N2 52N4 55N3 56N3 65N7 70N8 73N4 74N5 75N4 75N5 75N7 77N1 77N6 78N2 78N3 79N2 79N3 79N4 79N6 81N4 81N5 81N6
1.452	-	1.456	(25)	4N1 4N4 4N5 7N4 7N5 33N4 36N1 36N3 36N5 38N2 38N3 51N3 51N5 55N5 73N8 74N2 74N4 75N1 75N2 75N3 75N6 75N8 79N1 79N8 80N8
1.456	-	1.460	(4)	4N2 36N4 38N5 51N4
1.460	-	1.464	(0)	
1.464	-	1.468	(0)	
1.468	-	1.472	(1)	73N7
1.472	-	1.476	(1)	73N5
1.476	-	1.480	(1)	72N8

EOCTESTS

VARIABLE NO. 29 MANUFACTURERS TESTS NO5 EOC VOLTAGE (CHG C/10 16 HR 22 DEGREES C) BY PACK*CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.39100	1.46900	.780000E-01	488	1.44273	.917733E-02

1.386	-	1.393	(1)	61N3
1.393	-	1.400	(0)	
1.400	-	1.407	(0)	
1.407	-	1.414	(0)	
1.414	-	1.421	(0)	
1.421	-	1.428	(46)	2N1 2N2 2N3 2N4 2N5 5N1 5N3 5N4 12N1 12N2 15N1 20N1 20N2 20N3 20N4 20N5 23N1 23N2 23N3 23N4 23N5 26N1 26N2 29N1 29N2 35N1 35N2 35N3 35N4 40N1 40N2 41N1 41N2 46N1 46N2 49N2 49N3 49N4 49N5 56N2 59N1 59N2 64N1 64N2 64N3 64N4
1.428	-	1.435	(21)	4N1 4N2 4N3 5N2 7N1 7N2 13N2 15N2 18N1 18N2 21N1 21N2 35N5 40N3 40N4 40N5 46N4 49N1 54N3 56N1 64N5
1.435	-	1.442	(95)	4N4 5N5 7N4 9N4 10N1 10N2 10N5 13N1 13N3 13N4 18N3 18N4 18N5 21N3 21N4 21N5 28N1 28N2 28N3 28N5 31N1 31N3 31N4 31N5 33N1 33N2 36N4 39N4 43N1 43N2 43N3 43N4 44N1 44N2 48N3 48N4 48N5 50N5 51N1 51N2 56N3 57N3 57N4 57N5 58N1 62N2 62N3 62N4 62N5 65N1 65N2 65N3 66N1 66N3 67N2 67N3 68N1 68N4 68N5 68N8 69N4 69N6 69N7 69N8 70N4 70N5 70N6 70N7 70N8 71N2 71N4 71N5 71N6 71N7 71N8 72N3 72N4 73N1 73N2 73N3 74N1 74N2 74N3 78N1 78N4 78N5 78N6 78N8 81N2 83N1 83N2 86N4 86N7 86N8 87N3
1.442	-	1.449	(254)	1N1 1N2 1N3 1N4 1N5 3N1 3N2 3N4 3N5 6N1 6N2 6N3 6N4 6N5 7N3 8N1 8N2 8N5 9N1 9N2 9N3 9N5 10N3 10N4 11N1 11N2 11N3 11N4 11N5 13N5 14N1 14N2 14N3 14N4 14N5 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 19N1 19N2 19N3 19N4 19N5 22N2 22N5 24N1 24N2 25N1 25N2 25N3 25N4 25N5 27N1 27N2 27N3 27N4 27N5 28N4 30N1 30N2 30N3 30N4 30N5 31N2 32N1 32N2 32N3 32N4 32N5 33N5 34N2 34N4 36N2 36N3 37N1 37N2 37N3 37N5 38N1 38N2 38N4 39N1 39N2 39N3 39N5 42N1 42N2 42N3 42N4 42N5 43N5 44N3 44N4 44N5 45N1 45N2 45N3 45N4 45N5 47N1 47N2 47N3 47N4 47N5 48N2 50N1 50N2 50N3 50N4 51N3 52N3 52N5 53N1 53N2 53N4 53N5 55N1 55N2 55N3 56N4 56N5 58N2 58N3 58N4 58N5 60N1 60N2 60N3 60N4 60N5 61N1 61N2 61N4 61N5 63N1 63N2 63N3 63N4 63N5 65N4 65N5 65N6 65N8 66N2 66N4 66N6 66N7 66N8 67N1 67N4 67N7 67N8 68N2 68N3 68N6 68N7 69N1 69N2 69N3 69N5 70N1 70N2 70N3 71N1 71N3 72N1 72N2 72N5 72N6 72N7 72N8 73N4 73N5 73N6 73N8 74N4 74N5 74N6 74N7 74N8 76N1 76N2 76N3 76N4 76N5 76N6 77N2 77N3 77N4 77N7 77N8 78N2 78N3 78N7 79N1 79N2 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N1 81N4 81N5 81N7 81N8 82N1 82N2 82N4 82N5 83N3 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N4 84N5 84N6 84N7 84N8 85N1 85N2 85N3 85N4 85N5 85N6 85N7 85N8 86N1 86N2 86N3 86N5 86N6 87N1 87N2
1.449	-	1.456	(38)	3N3 4N5 7N5 8N3 8N4 22N1 22N3 22N4 33N3 33N4 34N1 34N3 34N5 36N1 36N5 37N4 38N3 38N5 51N4 51N5 52N1 52N2 52N4 53N3 55N4 55N5 59N5 66N5 67N5 67N6 73N7 76N7 76N8 77N1 77N5 77N6 81N6 82N3
1.456	-	1.463	(18)	41N4 46N5 48N1 57N1 57N2 59N3 59N4 62N1 65N7 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 79N3
1.463	-	1.470	(15)	12N3 12N4 12N5 15N3 15N4 15N5 26N3 26N4 26N5 29N3 29N4 29N5 41N3 41N5 46N3

EOCTEST6

VARIABLE NO. 30 MANUFACTURERS TESTS NV6 EOC VOLTAGE (CHG C/10 16 HR 38 DEGREES C) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.37400	1.48800	.114000	495	1.40077	.741165E-02

1.370	-	1.380	(2)	12N5 80N2
1.380	-	1.390	(18)	15N3 76N2 76N3 76N4 76N6 76N7 76N8 83N1 83N4 83N5 84N4 84N6 84N7 84N8 85N8 86N4 86N7 86N8
1.390	-	1.400	(177)	1N4 1N5 2N1 2N2 3N2 4N3 4N4 5N1 5N2 6N3 6N4 6N5 7N3 7N4 12N1 12N2 12N3 12N4 13N3 15N1
				15N2 15N4 15N5 16N2 18N1 18N5 19N1 19N2 20N1 20N2 21N1 21N2 21N3 21N4 21N5 23N1 23N2 24N1 24N2 25N1
				26N2 26N3 26N4 26N5 29N1 29N2 29N3 29N4 29N5 31N3 31N5 33N1 33N2 35N2 36N2 37N1 38N1 38N2 39N1 39N2
				40N1 40N2 41N1 41N2 41N3 41N4 41N5 43N3 44N2 45N1 46N1 46N2 46N3 46N4 46N5 48N1 48N2 49N2 50N1 50N2
				51N1 51N2 53N2 54N2 54N4 54N5 56N1 56N2 57N1 57N2 57N3 59N1 59N2 59N3 59N4 59N5 62N1 62N3 64N1 64N2
				64N3 64N4 64N5 65N5 65N6 65N7 66N5 66N6 66N7 68N4 68N6 72N6 73N4 73N7 73N8 74N4 74N5 74N6 74N7 74N8
				76N1 76N5 77N1 77N2 77N3 77N5 77N6 77N7 77N8 78N7 78N8 79N1 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N3
				80N4 80N5 80N6 80N7 80N8 81N4 81N5 81N6 81N7 81N8 82N1 82N2 82N3 82N4 82N5 83N2 83N3 83N6 83N7 83N8
				84N1 84N3 84N5 85N1 85N2 85N3 85N4 85N5 85N6 86N1 86N2 86N3 86N5 86N6 87N1 87N2 87N3
1.400	-	1.410	(262)	1N1 1N2 2N3 2N4 2N5 3N1 3N3 3N4 3N5 4N1 4N2 4N5 6N1 6N2 7N1 7N2 7N5 8N1 8N2 8N4
				8N5 9N1 9N2 9N3 9N4 9N5 10N1 10N2 10N3 10N4 10N5 11N1 11N2 11N3 11N4 11N5 13N1 13N2 13N4 13N5
				14N1 14N2 14N3 14N4 14N5 16N1 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 18N2 18N3 18N4 19N3 19N4 19N5
				20N5 22N1 22N2 22N3 22N4 22N5 23N3 23N4 23N5 24N3 24N4 24N5 25N1 25N2 25N3 25N4 25N5 27N1 27N2 27N3
				27N4 27N5 28N1 28N2 28N3 28N4 28N5 30N1 30N2 30N3 30N4 30N5 31N1 31N2 31N4 32N1 32N2 32N3 32N4 32N5
				33N3 33N5 34N1 34N2 34N3 34N4 34N5 35N1 35N3 35N4 35N5 36N1 36N3 36N4 37N2 37N3 37N4 37N5 38N4 38N5
				39N3 39N4 40N3 40N4 40N5 42N1 42N2 42N3 42N4 42N5 43N1 43N2 43N4 43N5 44N1 44N3 44N5 45N2 45N3 45N4
				45N5 47N1 47N2 47N4 47N5 48N3 48N4 48N5 51N3 51N4 52N1 52N2 52N3 52N4 52N5 53N1 54N1 55N1 55N2 55N3
				55N4 55N5 56N3 56N4 56N5 57N4 57N5 58N1 58N2 58N3 58N4 58N5 60N1 60N2 60N3 60N4 60N5 61N1 61N2 61N3
				61N4 61N5 62N2 62N4 62N5 63N1 63N2 63N3 63N4 63N5 65N1 65N2 65N3 65N4 65N8 66N1 66N2 66N3 66N4 66N8
				67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N1 68N2 68N5 68N7 68N8 69N1 69N3 69N4 69N5 69N6 69N7 69N8
				70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 72N1 72N2 72N3 72N4
				72N5 72N7 72N8 73N2 73N3 73N5 73N6 75N1 75N2 75N3 75N4 75N5 75N6 77N4 78N1 78N2 78N3 78N4 78N5 78N6
				84N2 85N7
1.410	-	1.420	(35)	1N3 5N3 5N4 5N5 8N3 20N3 20N4 33N4 36N5 38N3 39N5 44N4 47N3 49N3 49N4 49N5 50N3 50N4 50N5 51N5
				53N3 53N4 53N5 54N3 68N3 69N2 73N1 74N1 74N2 74N3 75N7 75N8 79N2 81N1 81N2
1.420	-	1.430	(0)	
1.430	-	1.440	(0)	
1.440	-	1.450	(0)	
1.450	-	1.460	(0)	
1.460	-	1.470	(0)	
1.470	-	1.480	(0)	
1.480	-	1.490	(1)	49N1

EOCTEST/

VARIABLE NO. 31 MANUFALTURERS TESTS NO7 EOC VOLTAGE (CHG C/20 72 HR 0 DEGREES C)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.46700	1.49100	.240000E-01	487	1.47690	.484943E-02

1.466	-	1.468	(3)	31N3 71N5 84N8
1.468	-	1.470	(24)	6N4 6N5 19N2 23N1 31N4 39N1 39N2 43N3 43N4 62N3 62N4 62N5 67N4 67N7 67N8 69N6 70N6 70N8 71N4 71N6 71N7 71N8 84N6 84N7
1.470	-	1.472	(40)	4N5 6N3 10N3 12N2 13N4 13N5 19N1 20N2 23N5 24N1 24N2 28N2 28N4 28N5 33N1 40N1 47N1 48N2 48N4 48N5 50N1 50N2 53N2 54N4 57N3 59N1 64N2 64N5 66N8 67N6 68N5 69N5 69N7 69N8 70N7 83N2 83N4 83N5 86N4 86N7
1.472	-	1.474	(77)	1N4 1N5 2N2 4N3 5N2 6N2 7N2 10N1 10N4 10N5 15N1 15N2 16N1 25N3 26N1 26N2 28N1 28N3 29N1 29N2 30N1 30N2 30N3 31N5 35N1 35N2 38N4 39N4 41N1 41N5 42N1 43N1 44N1 45N1 45N2 46N1 46N2 46N4 48N3 49N1 49N2 54N2 54N5 57N5 59N2 59N3 59N5 60N1 60N2 62N2 63N1 64N1 64N3 64N4 65N6 66N4 66N6 66N7 67N5 68N4 68N6 68N7 68N8 69N4 72N3 72N4 72N5 73N3 81N1 83N1 83N3 83N8 84N4 84N5 85N7 85N8 86N8
1.474	-	1.476	(45)	1N2 5N1 6N1 9N4 12N1 16N3 16N4 16N5 19N3 23N2 24N4 25N5 33N5 37N5 38N2 40N2 41N3 41N4 42N4 43N5 45N4 46N3 57N4 60N3 60N5 63N2 63N3 63N4 65N4 65N5 65N8 70N4 70N5 76N2 80N5 80N6 80N7 83N6 83N7 85N4 85N5 85N6 86N1 86N3 86N5
1.476	-	1.478	(70)	1N1 2N1 4N1 4N2 11N1 11N3 11N4 11N5 12N4 12N5 13N3 15N3 16N2 19N4 20N5 22N4 22N5 25N1 25N2 25N4 26N3 26N4 29N5 30N4 30N5 32N2 32N3 33N2 33N4 34N1 41N2 42N2 42N3 44N2 44N3 45N3 45N5 46N5 47N3 51N1 52N3 53N1 57N1 58N1 59N4 60N4 61N2 61N4 61N5 62N1 63N5 65N7 66N5 71N3 72N1 72N6 73N2 74N2 76N1 77N1 77N8 80N1 80N3 80N4 84N1 84N2 84N3 85N1 85N2 87N2
1.478	-	1.480	(104)	1N3 2N4 2N5 3N1 3N2 4N4 7N1 7N3 9N1 9N3 9N5 11N2 12N3 14N3 14N4 14N5 15N4 15N5 17N1 17N2 17N4 17N5 19N5 20N1 21N5 22N1 23N3 23N4 24N3 24N5 26N5 27N1 27N2 27N3 27N5 29N3 29N4 32N1 32N4 33N3 36N2 36N4 37N4 38N1 38N3 39N3 42N5 44N4 44N5 47N2 47N4 48N1 49N3 50N3 50N4 50N5 51N3 51N4 53N5 54N1 54N3 55N1 55N2 56N2 56N3 57N2 59N2 58N3 58N4 58N5 61N1 65N1 65N2 65N3 66N1 66N2 67N1 67N3 68N1 71N2 72N2 72N7 72N8 73N1 73N4 73N5 73N7 77N2 77N3 77N4 77N5 77N6 77N7 78N3 78N4 78N8 79N5 79N6 79N7 80N2 80N8 81N2 86N2 86N6
1.480	-	1.482	(25)	3N4 3N5 8N2 9N2 17N3 21N1 21N2 22N2 27N4 37N1 37N2 52N4 61N3 66N3 68N2 70N1 70N3 76N3 78N1 78N5 78N6 78N7 79N2 79N4 79N8
1.482	-	1.484	(44)	2N3 3N3 7N4 8N1 8N5 14N1 14N2 18N4 20N3 21N4 32N5 34N1 34N2 35N4 35N5 36N3 39N5 40N4 47N5 49N4 49N5 51N2 52N1 52N2 53N4 55N4 56N4 56N5 67N2 68N3 69N1 69N3 70N2 73N6 74N1 75N4 76N4 76N5 76N6 78N2 79N1 79N3 82N4 82N5
1.484	-	1.486	(44)	5N3 5N5 7N5 8N3 8N4 18N3 18N5 20N4 22N3 34N3 34N4 34N5 35N3 36N5 37N3 40N3 40N5 51N5 52N5 53N3 55N3 55N5 56N1 69N2 71N1 73N8 74N3 74N4 74N5 74N6 75N1 75N2 75N3 75N5 76N7 76N8 81N5 81N6 81N7 82N1 82N2 85N3 87N1 87N3
1.486	-	1.488	(4)	5N4 21N3 38N5 82N3
1.488	-	1.490	(4)	74N7 75N6 81N4 81N8
1.490	-	1.492	(3)	74N8 75N7 75N8

EOCPRES1 MANUFACTURERS TESTS NOT EOC PRESSURE (CMG C/2 150MIN 22 DEGREES C)

VARIABLE NO. 32 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
-3.50000	29.0000	32.5000	491	6.08452	3.81384

-6.000	-	-3.000	(1)	71N2
-3.000	-	0.	(0)	
0.	-	3.000	(71)	1N4 3N1 3N4 3N5 6N4 8N2 8N3 8N4 8N5 14N3 14N5 17N1 17N2 17N5 19N2 22N2 22N3 24N5 32N2 34N2 37N1 37N2 37N3 37N4 39N3 39N4 44N4 44N5 50N1 50N2 52N1 52N4 52N5 55N1 55N3 55N5 58N1 61N3 61N5 66N3 70N1 71N1 71N3 71N7 72N1 72N5 75N5 75N7 75N8 78N1 78N4 78N5 78N6 78N7 79N4 82N3 82N4 82N5 83N2 83N4 83N5 83N6 83N7 84N4 84N7 85N3 85N4 85N8 86N2 86N3 86N6
3.000	-	6.000	(237)	1N1 1N2 1N3 1N5 2N1 3N2 3N3 4N1 4N3 5N5 6N1 6N3 6N5 9N1 9N2 9N3 9N4 9N5 10N3 11N1 11N2 11N3 11N4 11N5 12N1 12N2 14N1 14N2 14N4 15N3 16N1 16N3 16N4 16N5 17N3 17N4 18N1 19N1 19N3 19N4 19N5 20N1 20N4 22N1 22N5 24N1 24N2 24N3 24N4 25N1 25N2 25N3 25N4 27N1 27N2 27N3 27N4 27N5 30N1 30N2 30N4 32N1 32N3 32N4 32N5 33N1 33N2 34N1 34N3 34N4 37N5 38N1 38N2 39N1 39N2 39N5 40N1 40N2 42N1 42N4 42N5 44N1 44N2 44N3 45N1 45N2 45N5 46N4 46N5 47N1 47N2 47N3 47N4 47N5 51N1 51N2 52N2 52N3 53N2 53N3 53N5 56N1 56N2 58N2 58N3 58N4 58N5 59N3 59N4 59N5 60N1 60N4 60N5 61N1 61N2 61N4 63N1 63N2 63N3 63N4 64N3 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 66N1 66N2 66N4 66N5 66N6 66N7 66N8 67N1 67N2 67N3 67N4 67N5 67N6 67N7 68N1 68N2 68N3 68N4 68N5 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N7 69N8 70N2 70N3 70N5 70N6 70N7 70N8 71N4 71N5 71N6 71N8 72N2 72N4 72N6 73N2 73N3 73N5 73N7 73N8 74N1 74N2 74N3 74N7 74N8 75N1 75N2 75N3 75N4 75N6 76N5 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N2 78N3 78N6 79N1 79N2 79N3 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N2 81N4 81N6 81N7 82N1 82N2 83N1 83N3 83N6 84N1 84N2 84N3 84N5 84N6 84N8 85N1 85N5 85N6 85N7 86N4 86N5 86N7 86N8 87N1 87N2
6.000	-	9.000	(78)	2N3 5N1 5N3 6N2 7N1 7N2 7N4 8N1 10N2 12N4 13N1 13N2 15N1 15N2 15N4 16N2 18N2 18N3 21N1 21N2 22N4 25N5 26N1 26N2 29N1 29N2 30N3 30N5 31N1 31N2 31N5 35N2 35N4 41N1 41N2 41N3 42N2 43N2 45N3 45N4 46N1 46N2 46N3 48N1 49N4 49N5 50N3 50N4 53N1 53N4 54N2 57N5 59N1 63N5 64N1 64N2 64N4 67N8 69N6 70N4 72N3 72N7 72N8 73N4 73N6 74N4 74N5 74N6 76N2 76N3 76N4 76N6 76N7 76N8 81N1 81N5 85N2 86N1
9.000	-	12.00	(70)	2N2 2N5 4N2 4N4 5N2 5N4 7N3 10N5 12N3 12N5 13N4 13N5 15N5 18N4 18N5 20N2 21N3 21N4 23N1 23N2 26N3 26N4 26N5 28N1 28N3 28N4 28N5 29N3 29N4 29N5 31N3 31N4 35N1 35N3 35N5 36N2 36N3 40N3 40N4 41N4 41N5 42N3 43N3 43N5 48N2 48N3 48N4 48N5 49N1 49N2 49N3 50N5 54N1 54N4 54N5 55N4 56N4 56N5 57N1 57N2 57N4 59N2 60N3 62N1 62N2 64N5 73N1 76N1 81N8 87N3
12.00	-	15.00	(15)	2N4 7N5 13N3 20N5 21N5 23N4 23N5 38N4 38N5 40N5 43N1 43N4 51N3 57N3 62N3
15.00	-	18.00	(12)	10N4 20N3 23N3 28N2 33N3 33N4 33N5 36N4 51N4 54N3 56N3 62N5
18.00	-	21.00	(4)	4N5 36N1 36N5 51N5
21.00	-	24.00	(1)	10N1
24.00	-	27.00	(0)	
27.00	-	30.00	(2)	38N3 62N4

EOCPRES2

VARIABLE NO. 33 MANUFACTURERS TESTS NO2 EOC PRESSURE (CHG C/2 150MIN 22 DEGREES C) BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.500000	44.0000	43.5000	494	12.9190	7.62226

0.	-	4.000	(23)	3N4 3N5 8N1 8N2 8N4 14N5 17N4 17N5 34N2 34N5 37N1 37N2 44N4 44N5 52N1 52N4 55N2 55N4 55N5 58N1 83N2 83N6 86N2
4.000	-	8.000	(112)	1N1 1N2 1N3 1N5 3N1 3N2 3N3 5N4 5N5 6N1 6N4 6N5 8N3 8N5 9N3 9N4 9N5 14N3 14N4 16N3 16N4 17N1 17N2 17N3 19N1 19N3 19N4 19N5 22N1 22N2 22N3 22N5 24N1 24N2 24N3 24N4 24N5 25N4 27N3 27N4 27N5 32N2 32N3 32N4 32N5 34N3 34N4 37N3 37N4 37N5 39N3 39N4 39N5 42N4 42N5 44N1 44N2 44N3 45N1 47N1 47N2 47N3 47N4 47N5 50N1 50N4 52N2 52N5 53N3 55N1 55N3 58N2 58N3 58N4 58N5 60N2 60N5 61N2 61N3 61N4 61N5 63N3 63N4 65N1 65N2 65N4 70N8 73N4 75N3 75N4 75N5 75N7 77N1 78N6 83N1 83N3 83N4 83N5 83N7 84N1 84N2 84N3 84N4 84N5 84N6 85N1 85N4 85N8 84N5 86N6 86N7 86N8
8.000	-	12.00	(125)	1N4 2N3 2N5 5N1 5N3 6N2 6N3 9N1 9N2 11N1 11N2 11N3 11N4 11N5 14N1 14N2 15N1 16N1 16N2 16N5 19N2 20N1 20N4 21N3 22N4 25N1 25N2 25N3 25N5 27N1 27N2 30N1 30N2 30N3 30N4 30N5 32N1 33N1 33N2 34N1 39N1 39N2 42N1 42N3 45N2 45N3 45N4 45N5 46N4 46N5 49N4 50N2 50N3 50N5 52N3 53N1 53N2 53N4 53N5 54N2 59N3 59N4 59N5 60N1 60N3 60N4 61N1 63N1 63N2 63N5 65N3 66N1 66N2 66N3 66N8 67N1 67N2 67N3 67N5 68N1 68N2 70N5 70N6 70N7 71N4 71N5 71N6 71N7 72N5 73N3 73N5 73N7 74N1 74N3 75N1 75N2 75N6 75N8 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N3 78N4 78N5 78N7 78N8 79N1 79N3 79N4 79N6 79N7 79N8 80N2 80N3 81N2 83N8 84N7 84N8 85N2 85N3 85N5 85N6 86N3
12.00	-	16.00	(82)	2N1 2N2 2N4 4N3 4N4 5N2 7N4 12N1 12N2 15N2 18N1 18N3 18N4 20N3 20N5 21N1 21N2 21N5 23N1 23N2 23N4 29N1 29N2 35N2 35N3 35N4 35N5 40N1 40N2 40N3 41N1 42N2 46N1 48N1 48N2 48N5 49N2 49N5 51N1 54N1 56N1 56N2 57N5 59N1 62N2 64N1 64N2 64N3 64N4 65N5 66N7 67N4 67N6 67N7 67N8 68N8 69N5 69N7 69N8 70N1 70N4 71N8 72N3 72N4 72N6 72N7 73N2 74N8 76N2 78N2 79N2 80N1 80N8 81N4 81N6 82N3 82N5 85N7 86N1 86N4 87N1 87N2
16.00	-	20.00	(67)	4N1 7N3 10N2 13N1 15N3 18N5 20N2 21N4 23N3 23N5 26N1 26N2 29N4 31N1 31N2 35N1 36N2 36N3 38N2 39N3 40N4 40N5 41N2 46N2 51N2 54N4 56N4 57N2 57N4 59N2 62N1 65N6 65N7 65N8 66N4 68N3 68N4 68N5 68N6 68N7 69N1 69N2 69N3 69N4 70N2 70N3 71N1 71N2 72N8 73N1 73N6 73N8 74N2 74N4 74N5 74N6 74N7 79N5 80N4 80N6 80N7 81N1 81N5 81N8 82N1 82N4 87N3
20.00	-	24.00	(33)	4N2 7N1 7N5 10N3 12N4 13N2 15N4 18N2 26N5 28N1 28N3 29N5 31N5 38N1 41N3 43N2 49N1 49N3 54N3 54N5 56N5 57N1 57N3 62N3 64N5 66N5 66N6 71N3 72N1 72N2 76N4 80N5 82N2
24.00	-	28.00	(19)	7N2 10N5 12N3 25N4 26N4 28N5 29N3 31N4 41N4 43N1 43N5 46N3 48N3 48N4 62N5 76N5 76N6 76N7 81N7
28.00	-	32.00	(14)	10N1 13N3 13N4 13N5 28N2 31N3 36N4 38N5 41N5 43N3 43N4 56N3 76N1 76N3
32.00	-	36.00	(7)	12N5 15N5 26N3 33N3 38N4 51N4 76N8
36.00	-	40.00	(6)	4N5 33N5 36N1 36N5 51N5 62N4
40.00	-	44.00	(2)	10N4 51N3
44.00	-	48.00	(1)	33N4

EOCPRES3

VARIABLE NO. 34 MANUFACTURERS TESTS NO3 EOC PRESSURE (CMG C/8 12 HR 22 DEGREES C) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
2.50000	71.0000	68.5000	492	21.3394	12.2114

0.	-	6.000	(37)	3N1 3N2 3N4 3N5 6N5 8N1 8N2 8N5 14N5 17N2 17N3 17N4 17N5 19N1 22N2 24N1 24N5 32N3 32N5 34N2 34N5 37N1 37N2 37N3 37N4 39N4 44N5 52N1 52N4 52N5 55N2 55N3 55N4 55N5 58N1 58N5 61N5
6.000	-	12.00	(81)	1N2 1N4 1N5 3N3 6N1 6N3 8N3 8N4 9N3 9N4 9N5 14N3 14N4 17N1 19N2 19N3 19N4 19N5 22N3 22N5 24N2 24N4 27N3 27N4 27N5 32N2 32N4 34N1 34N3 34N4 37N5 39N1 39N2 44N1 44N2 44N3 44N4 47N2 47N3 47N4 47N5 48N1 50N1 50N2 50N3 52N2 52N3 55N1 57N1 57N2 58N2 58N3 58N4 59N4 61N2 61N3 61N4 62N1 63N3 65N1 65N2 65N3 66N1 66N2 66N3 67N1 67N2 67N3 68N1 68N2 75N3 75N4 75N5 75N7 75N8 78N4 78N6 79N3 79N6 79N7 85N4
12.00	-	18.00	(84)	1N1 1N3 2N1 2N2 5N1 6N2 6N4 9N2 11N1 11N2 11N3 14N1 14N2 16N1 16N3 20N2 20N4 21N3 22N1 22N4 23N1 23N2 24N3 25N1 25N2 25N4 27N1 27N2 30N1 30N3 30N4 32N1 35N2 39N3 39N5 40N1 42N1 42N4 42N5 45N1 45N2 45N4 47N1 49N2 50N4 53N1 53N2 53N3 53N4 53N5 54N2 54N4 59N3 59N5 60N2 60N5 63N1 63N2 63N4 63N5 69N3 69N1 69N2 69N3 75N1 75N2 75N6 77N1 77N2 77N3 77N5 77N6 77N8 78N1 78N5 78N8 79N8 80N3 83N1 83N2 83N3 84N2 84N4 86N2
18.00	-	24.00	(96)	2N3 2N4 2N5 4N3 4N4 5N2 5N3 5N4 7N4 9N1 11N4 11N5 12N1 16N2 18N3 18N4 18N5 20N1 20N5 21N1 21N2 21N4 21N5 23N3 23N4 25N5 28N3 30N2 30N5 33N2 35N1 35N5 40N2 40N3 42N2 42N3 45N3 45N5 46N4 46N5 48N2 48N5 49N1 49N4 49N5 50N5 54N1 54N5 56N1 57N4 57N5 60N1 60N3 60N4 61N1 64N3 64N4 65N6 67N6 70N1 70N2 70N3 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 72N1 72N2 72N3 72N5 73N5 73N7 74N1 74N3 77N4 77N7 78N2 78N3 78N7 79N2 79N4 79N5 80N5 84N1 84N3 84N5 84N6 86N4 86N6 86N7 86N8
24.00	-	30.00	(85)	5N5 7N1 10N3 12N2 15N1 15N2 18N1 20N3 23N5 24N1 26N2 28N1 28N2 29N1 29N2 31N5 33N1 35N3 35N4 36N3 38N2 40N4 40N5 41N1 41N2 43N1 46N1 46N2 49N3 51N1 54N3 56N2 56N4 57N3 59N1 59N2 62N2 62N3 62N5 64N1 64N2 67N4 67N5 67N7 67N8 68N6 69N4 69N5 69N6 69N7 69N8 70N4 70N5 70N6 70N7 72N4 72N6 72N7 72N8 73N2 73N3 73N4 73N6 74N2 74N5 79N1 80N2 80N7 80N8 81N1 81N2 83N4 83N5 83N6 83N7 84N7 84N8 85N1 85N2 85N3 85N5 85N8 86N3 86N5 87N1
30.00	-	36.00	(64)	4N1 4N2 7N3 10N1 10N2 10N5 13N1 13N2 13N3 13N4 13N5 18N2 26N5 28N4 28N5 29N4 29N5 31N1 31N2 31N3 31N4 36N2 36N4 43N3 43N4 43N5 48N3 48N4 51N2 56N3 56N5 62N4 64N5 65N4 65N5 65N7 65N8 66N4 66N6 66N7 66N8 68N4 68N5 68N7 68N8 73N1 73N8 74N4 74N6 74N7 74N8 80N1 80N4 80N6 81N4 81N5 81N8 82N3 83N8 85N6 85N7 86N1 87N2 87N3
36.00	-	42.00	(16)	7N2 10N4 12N3 15N3 15N4 26N4 29N3 36N5 38N1 43N2 51N5 66N5 81N6 81N7 82N1 82N5
42.00	-	48.00	(10)	12N4 26N3 33N3 38N5 41N3 41N4 51N4 76N2 82N2 82N4
48.00	-	54.00	(7)	7N5 12N5 15N5 33N5 38N4 41N5 46N3
54.00	-	60.00	(7)	4N5 36N1 38N3 51N3 76N5 76N6 76N7
60.00	-	66.00	(2)	33N4 76N4
66.00	-	72.00	(3)	76N1 76N3 76N9

EOCP-ES4

VARIABLE NO. 35 MANUFACTURERS TESTS NO4 EOC PRESSURE (CHG C/10 48HR 22 DEGREES C)
BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
4.00000	133.000	129.000	490	40.4837	25.3519

0.	-	10.00	(22)	3N4 3N5 6N5 8N1 8N2 8N5 17N3 17N5 19N2 22N2 24N5 34N2 34N5 37N1 37N2 37N3 39N1 52N1 52N4 55N2 55N3 55N4
10.00	-	20.00	(81)	1N5 3N1 3N2 3N3 6N2 6N3 8N3 8N4 9N3 9N4 14N3 14N4 14N5 17N1 17N2 17N4 19N1 19N3 19N4 19N5 22N3 22N5 24N1 24N2 24N3 24N4 27N3 32N2 32N4 32N5 34N3 34N4 37N4 37N5 39N3 39N4 44N1 44N2 44N3 44N4 44N5 47N3 47N4 50N1 50N2 50N3 52N2 52N3 52N5 53N2 55N5 58N1 58N2 58N3 58N4 58N5 61N2 61N3 61N4 61N5 65N1 65N2 65N3 66N3 67N1 67N2 67N3 68N1 68N2 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 79N3 79N4 79N6 79N8
20.00	-	30.00	(104)	1N1 1N2 1N4 6N1 6N4 9N5 11N1 11N3 11N4 11N5 14N2 16N4 22N1 22N4 25N4 27N1 27N2 27N4 27N5 30N2 30N4 32N3 34N1 39N2 39N5 42N4 47N2 47N5 50N4 53N1 53N3 53N4 53N5 55N1 60N2 60N4 66N5 63N1 63N4 63N5 65N4 65N5 65N6 66N1 66N2 67N4 67N5 67N6 67N7 67N8 68N3 68N4 68N6 69N1 69N2 69N3 69N4 69N5 70N1 70N2 70N3 70N5 70N8 71N1 71N2 71N3 71N4 71N6 71N8 72N1 72N2 72N3 72N4 73N2 73N7 74N2 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N4 78N5 78N6 78N7 78N8 79N1 79N2 79N5 79N7 80N5 80N6 80N7 83N1 83N2 85N4 85N5 85N6 87N1
30.00	-	40.00	(81)	1N3 9N2 14N1 16N1 16N3 25N3 26N3 30N1 30N5 32N1 42N1 42N3 42N5 45N1 45N2 45N3 45N4 47N1 60N1 60N3 63N3 65N8 66N4 66N7 66N8 68N5 68N7 68N8 69N6 69N7 69N8 70N4 70N6 70N7 71N5 71N7 72N5 72N6 72N7 73N1 73N3 73N5 73N6 74N1 74N3 74N5 74N6 78N3 80N1 80N2 80N3 80N4 80N8 81N1 81N2 81N4 83N3 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N4 84N5 84N6 84N7 84N8 85N3 85N7 85N8 86N2 86N3 86N4 86N5 86N6 86N7 86N8 87N3
40.00	-	50.00	(44)	9N1 11N2 12N1 15N2 15N3 15N4 15N5 16N2 16N5 20N4 25N1 25N2 25N5 26N5 30N3 31N3 41N5 42N2 45N5 46N3 46N5 48N2 48N3 49N5 59N3 61N1 63N2 65N7 66N5 66N6 72N8 73N4 73N8 74N4 74N7 74N8 81N5 81N7 81N8 82N1 85N1 85N2 86N1 87N2
50.00	-	60.00	(39)	2N3 5N2 5N5 10N2 12N2 12N3 12N4 13N2 13N3 21N2 21N3 21N5 23N3 26N1 26N4 28N4 29N3 29N4 29N5 31N1 31N5 41N3 41N4 43N4 43N5 48N1 57N2 57N3 57N5 62N1 62N3 62N4 64N3 76N6 81N6 82N2 82N3 82N4 82N5
60.00	-	70.00	(51)	2N2 2N4 2N5 5N1 5N3 10N1 10N3 10N4 10N5 12N5 13N1 13N4 13N5 15N1 18N4 20N1 20N2 20N5 23N1 23N2 26N2 29N1 29N2 31N2 35N2 35N4 35N5 41N1 41N2 43N1 43N2 46N1 46N2 46N4 48N4 48N5 54N3 56N1 56N5 57N1 57N4 59N1 59N2 59N4 59N5 62N2 62N5 64N1 64N2 64N4 64N5
70.00	-	80.00	(30)	2N1 4N1 4N2 4N3 5N4 7N2 20N3 21N1 21N4 23N4 23N5 28N1 28N2 28N3 28N5 31N4 35N1 40N3 43N3 49N1 49N2 49N3 49N4 54N1 54N2 56N3 56N4 76N2 76N4 76N5
80.00	-	90.00	(12)	18N2 18N3 18N5 33N4 35N3 38N2 40N4 40N5 56N2 76N1 76N3 76N7
90.00	-	100.0	(9)	7N1 7N4 18N1 33N1 33N5 38N3 38N4 50N5 76N8
100.0	-	110.0	(10)	4N4 4N5 7N3 33N2 36N1 36N2 36N4 38N1 51N3 54N5
110.0	-	120.0	(2)	36N3 51N5
120.0	-	130.0	(3)	33N3 36N5 51N4
130.0	-	140.0	(2)	7N5 38N5

EOCPRESS

VARIABLE NO. 36 MANUFACTURERS TESTS NO5 EOC PRESSURE (CHG C/10 16HR 22 DEGREES C)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.500000	40.0000	39.5000	479	14.2547	9.34474

0.	-	3.000	(28)	4N1 5N2 7N2 8N2 12N1 12N2 14N5 15N1 17N5 19N2 20N1 20N4 23N1 23N2 26N1 35N1 35N2 35N4 40N3 46N2 46N4 49N2 49N4 49N5 55N4 59N5 64N3 64N4
3.000	-	6.000	(90)	1N3 1N4 1N5 2N3 2N4 2N5 3N4 3N5 4N2 4N3 5N3 5N4 5N5 6N5 7N1 7N4 8N1 9N4 10N2 13N1 13N2 14N3 14N4 15N2 17N3 17N4 18N1 18N2 18N4 18N5 20N3 20N5 21N1 21N2 21N3 21N5 22N2 23N3 23N4 23N5 24N1 24N2 26N2 29N1 29N2 31N1 33N1 34N2 35N3 35N5 37N1 37N2 37N3 38N2 39N4 39N5 40N4 41N1 41N2 44N2 44N5 46N1 46N5 49N1 49N3 50N5 52N1 52N4 53N5 55N3 56N1 56N2 57N2 58N1 58N2 59N1 59N2 59N3 59N4 60N2 61N2 61N5 64N1 64N2 75N1 75N4 75N5 75N7 75N8 77N1
6.000	-	9.000	(68)	1N1 3N1 3N2 3N3 4N4 8N5 9N3 16N4 16N5 18N3 19N1 19N3 21N4 22N3 22N5 27N5 31N2 32N2 32N3 32N4 32N5 33N2 34N4 34N5 35N3 36N4 37N4 39N1 39N2 40N5 42N5 43N2 44N1 44N3 44N4 45N1 45N2 47N1 47N2 47N3 47N5 48N1 50N2 50N3 50N4 51N1 51N2 52N2 52N5 53N4 54N3 55N1 55N5 56N3 56N4 57N1 58N4 58N5 61N4 62N1 63N1 63N2 64N5 75N2 75N3 75N6 77N4 77N6
9.000	-	12.00	(56)	6N1 6N2 6N3 6N4 8N3 8N4 9N2 9N5 11N1 11N2 11N3 11N4 11N5 14N1 14N2 16N1 16N3 17N1 17N2 19N4 19N5 22N1 25N2 27N1 27N3 27N4 28N5 29N4 29N5 30N1 30N4 32N1 34N1 34N3 37N5 39N3 42N1 42N4 47N4 48N2 50N1 52N3 53N1 53N2 56N5 58N3 60N1 60N4 60N5 63N3 63N5 77N2 77N3 77N5 77N7 77N8
12.00	-	15.00	(28)	9N1 10N5 12N3 16N2 22N4 25N1 25N3 25N4 27N2 30N2 30N3 30N5 38N1 42N2 45N3 45N4 45N5 57N5 61N1 63N4 65N1 65N2 65N3 67N1 70N1 79N3 79N6 79N8
15.00	-	18.00	(29)	10N3 25N5 25N5 29N3 36N5 42N3 51N5 60N3 66N1 66N2 66N3 67N2 67N3 67N5 67N6 68N1 68N2 68N3 70N3 71N1 71N2 71N3 71N6 72N1 72N2 79N2 79N4 79N5 80N6
18.00	-	21.00	(38)	1N2 7N3 7N5 12N4 15N3 15N4 36N2 38N5 41N3 43N4 48N4 48N5 65N4 67N7 68N4 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N7 70N2 71N4 72N5 73N7 78N5 78N6 79N1 79N7 80N1 80N5 80N7 80N8 83N1 86N2
21.00	-	24.00	(43)	28N1 41N4 41N5 43N5 46N3 51N4 62N2 65N5 65N6 65N8 66N4 66N7 67N8 68N5 69N6 69N8 70N4 70N7 70N8 71N5 71N8 72N3 72N4 72N7 73N2 73N3 73N5 73N6 74N1 74N2 74N3 78N1 78N2 78N4 78N8 80N2 80N3 80N4 81N1 83N2 85N4 85N6 87N1
24.00	-	27.00	(34)	12N5 15N5 26N4 28N4 33N3 48N3 57N3 66N8 67N4 70N5 71N7 72N6 72N8 73N4 74N6 76N2 78N3 78N7 81N2 81N8 83N3 83N5 83N7 84N2 84N3 84N4 84N6 84N7 85N8 86N5 86N7 86N8 87N2 87N3
27.00	-	30.00	(36)	13N5 26N3 31N3 31N5 33N5 38N4 43N1 57N4 62N3 62N4 66N6 70N6 73N1 73N8 74N4 74N5 74N7 74N8 76N5 76N6 81N4 81N5 81N7 83N4 83N6 83N8 84N1 84N5 84N8 85N1 85N3 85N5 85N6 85N7 86N3 86N4
30.00	-	33.00	(15)	13N4 28N3 31N4 43N3 51N3 65N7 76N1 76N3 76N4 76N7 81N6 82N1 82N3 85N2 86N1
33.00	-	36.00	(11)	4N5 10N1 10N4 13N3 36N1 38N3 62N5 66N5 76N8 82N2 82N5
36.00	-	39.00	(2)	28N2 82N4
39.00	-	42.00	(1)	33N4

EOCPRES6

VARIABLE NO. 37 MANUFACTURERS TESTS NO6 EOC PRESSURE (CHG C/10 16HR 38 DEGREES C)
BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.500000	43.0000	42.5000	490	11.3755	6.81818

0.	-	4.000	(40)	3N4 3N5 8N1 9N4 11N1 11N2 14N3 14N5 17N3 17N4 17N5 19N2 22N2 24N2 24N5 27N5 34N2 37N1 37N2 40N1 42N5 44N1 44N4 45N1 45N4 47N3 52N1 52N4 55N1 55N3 55N4 55N5 58N1 60N1 61N2 61N3 61N5 [illegible] 65N5 68N8
4.000	-	8.000	(123)	1N1 1N2 1N3 1N4 2N2 3N1 3N2 3N3 5N1 6N1 6N2 6N3 6N4 6N5 8N3 8N4 8N5 9N1 9N2 9N3 11N3 11N4 11N5 14N1 14N2 14N4 16N1 16N2 16N3 16N4 16N5 17N1 17N2 19N1 19N3 19N4 19N5 20N2 22N1 22N3 22N4 22N5 24N1 24N3 24N4 25N1 25N2 25N3 25N4 27N1 27N2 27N3 27N4 30N1 30N2 30N4 30N5 32N1 32N2 32N3 32N4 32N5 34N1 34N3 34N4 34N5 37N3 37N4 37N5 39N1 39N2 39N3 39N4 39N5 42N1 42N4 44N2 44N3 44N5 45N2 45N3 45N5 47N1 47N2 47N4 47N5 49N4 49N5 50N1 50N2 50N3 50N4 52N2 52N3 52N5 53N1 53N2 53N4 53N5 58N2 58N3 58N4 58N5 60N4 60N5 61N1 61N4 63N2 63N3 63N4 63N5 65N4 75N1 75N4 75N5 75N6 75N7 75N8 79N2 79N3 79N8 83N2 86N2
8.000	-	12.00	(111)	1N5 2N1 2N3 5N2 10N3 12N1 12N2 20N4 20N5 23N1 23N2 23N3 23N5 25N5 30N3 35N2 35N4 35N5 40N3 40N4 42N2 42N3 46N4 46N5 49N1 49N2 50N5 53N3 54N1 54N2 54N5 60N3 64N3 64N4 65N1 65N2 65N3 65N6 66N1 66N2 66N3 67N1 67N2 67N3 67N6 68N1 68N2 68N3 68N4 68N5 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 71N1 71N2 71N3 71N5 71N6 72N1 72N2 72N3 72N5 72N7 73N1 74N1 74N2 74N3 75N2 75N3 77N1 77N2 77N3 77N4 77N5 77N6 78N1 78N3 78N4 78N5 78N6 79N4 79N5 79N6 79N7 80N1 80N4 80N5 81N1 81N2 81N4 81N8 83N1 84N6 84N7 85N3 85N7 85N8 86N1 86N5 86N6 86N8 87N3
12.00	-	16.00	(117)	2N4 2N5 4N1 5N3 5N4 5N5 10N5 13N4 13N5 15N1 15N2 20N1 20N3 23N4 26N1 26N2 28N4 28N5 29N1 29N2 31N3 31N5 35N1 35N3 40N2 40N5 41N1 41N2 43N3 43N4 43N5 46N1 46N2 48N2 48N3 48N4 48N5 49N3 54N3 57N3 57N5 59N1 59N2 59N3 59N5 64N1 64N2 65N7 65N8 66N4 66N5 66N6 66N7 66N8 67N4 67N5 67N7 67N8 68N6 68N7 70N5 70N6 70N7 70N8 71N4 71N7 71N8 72N4 72N6 72N8 73N2 73N3 73N4 73N5 73N6 73N7 73N8 74N4 74N5 74N6 74N7 74N8 76N4 77N7 77N8 78N2 78N7 78N8 79N1 80N2 80N3 80N7 80N8 81N5 81N6 82N1 83N3 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N4 84N5 84N8 85N1 85N2 85N4 85N5 85N6 86N3 86N4 86N7 87N1 87N2
16.00	-	20.00	(37)	4N2 4N3 7N1 7N2 7N4 10N4 12N3 13N1 13N2 13N3 18N2 18N4 21N3 21N5 28N1 31N1 31N4 38N5 41N5 43N1 46N3 57N2 57N4 59N4 62N2 62N3 62N4 62N5 64N5 76N2 80N6 81N7 82N2 82N3 82N4 82N5 83N4
20.00	-	24.00	(36)	4N4 7N3 10N1 10N2 15N3 15N4 15N5 18N1 18N3 18N5 21N1 21N2 21N4 26N5 28N2 28N3 29N3 29N4 29N5 31N2 36N2 36N3 36N4 38N2 41N4 43N2 46N1 51N1 51N2 56N1 56N3 56N4 56N5 57N1 62N1 76N5 76N6 76N8
24.00	-	28.00	(13)	12N4 12N5 26N3 33N1 33N2 33N3 38N1 41N3 51N3 56N2 76N1 76N3 76N7
28.00	-	32.00	(4)	7N5 26N4 36N5 51N5
32.00	-	36.00	(2)	38N4 51N4
36.00	-	40.00	(2)	33N4 33N5
40.00	-	44.00	(3)	4N5 36N1 38N3

EOCPRES7

VARIABLE NO. 39 MANUFACTURERS TESTS NO7 EOC PRESSURE (CHG C/20 72HR 0 DEGREES C)
BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
5.00000	170.000	165.000	485	38.7309	28.6168

0.	-	10.00	(19)	6N5 8N1 8N2 8N5 17N5 19N2 24N5 34N2 34N3 34N5 37N3 37N4 39N4 52N1 52N4 52N5 55N2 55N3 55N4
10.00	-	20.00	(119)	1N3 1N4 1N5 3N1 3N2 3N3 3N4 3N5 6N2 6N3 8N3 8N4 17N1 17N2 17N3 17N4 19N1 19N5 22N1 22N2 22N3 22N4 22N5 24N1 24N2 24N3 24N4 27N1 32N2 34N4 37N1 37N2 37N5 39N1 39N2 39N3 44N1 47N3 50N1 50N2 50N3 50N4 52N2 52N3 53N1 53N2 53N3 55N5 58N4 58N5 61N4 61N5 63N5 65N1 65N2 65N3 65N4 66N1 66N2 66N3 67N1 67N2 67N3 67N5 67N6 68N1 68N4 68N5 68N6 68N7 68N8 69N2 69N4 69N5 69N6 69N7 70N3 70N5 71N1 71N2 71N4 71N5 71N6 71N7 71N8 72N1 72N2 72N4 72N5 72N7 73N2 74N2 77N1 77N2 77N3 77N6 78N1 78N3 78N4 78N5 78N6 78N8 79N4 79N6 79N7 79N8 80N5 81N1 83N1 83N2 84N4 84N6 84N7 85N3 85N4 86N2 86N6 86N7 87N1
20.00	-	30.00	(142)	1N1 1N2 6N1 6N4 9N3 9N4 11N1 14N2 14N3 14N4 14N5 16N3 16N4 19N3 19N4 27N3 27N4 27N5 30N2 30N4 30N5 32N3 32N4 32N5 34N1 39N5 41N5 42N4 44N2 44N3 44N4 44N5 45N4 47N2 47N4 47N5 53N4 53N5 55N1 58N1 58N2 58N3 60N2 60N4 60N5 61N2 61N3 63N3 63N4 65N5 65N6 65N7 65N8 66N4 66N7 66N8 67N4 67N7 67N8 68N3 69N1 69N3 69N8 70N1 70N2 70N4 70N6 70N7 70N8 71N3 72N3 72N6 72N8 73N1 73N3 73N4 73N5 73N6 74N1 74N3 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 77N4 77N5 77N7 77N8 78N2 78N7 79N1 79N2 79N3 79N5 80N1 80N2 80N3 80N4 80N6 80N7 80N8 81N2 81N4 81N5 81N6 81N7 81N8 82N1 82N3 82N4 82N5 83N3 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N5 84N8 85N5 85N6 85N7 85N8 86N1 86N3 86N4 86N5 86N8 87N2 87N3
30.00	-	40.00	(33)	9N2 9N5 11N3 11N5 12N3 14N1 15N3 16N5 25N1 25N3 25N4 27N2 30N1 30N3 32N1 41N4 42N3 42N5 45N1 45N2 46N3 46N4 46N5 47N1 48N3 59N3 60N1 63N1 66N6 76N4 82N2 85N1 85N2
40.00	-	50.00	(28)	9N1 11N2 11N4 12N2 15N5 16N1 16N2 25N2 25N5 26N5 28N4 31N3 42N1 42N2 43N4 43N5 45N3 45N5 48N2 59N5 60N3 61N1 63N2 64N3 64N5 66N5 76N2 76N6
50.00	-	60.00	(26)	5N2 10N3 10N4 10N5 12N4 12N5 13N4 13N5 15N4 23N5 26N3 29N3 31N5 40N1 41N3 43N1 43N3 48N4 54N2 57N2 57N3 57N5 62N4 64N2 64N4 76N5
60.00	-	70.00	(26)	2N4 2N5 12N1 13N3 15N2 23N1 26N2 26N4 28N1 29N1 29N4 29N5 41N2 46N1 46N2 48N1 48N5 49N5 54N4 59N1 59N4 62N1 62N2 62N5 76N1 76N3
70.00	-	80.00	(32)	2N2 2N3 4N1 4N5 5N1 5N3 5N5 7N2 10N1 15N1 20N1 20N2 20N4 20N5 23N3 26N1 28N2 28N3 28N5 29N2 31N4 33N4 35N2 35N5 41N1 49N1 54N1 57N1 59N2 64N1 76N7 76N8
80.00	-	90.00	(21)	2N1 4N2 5N4 20N3 21N5 23N2 23N4 33N5 35N1 35N4 36N1 36N4 38N3 38N4 40N3 51N3 54N3 54N5 56N2 56N3 57N4
90.00	-	100.0	(19)	4N3 7N1 7N3 7N4 18N4 21N3 21N4 33N1 35N3 36N2 36N5 38N2 40N2 40N5 49N2 49N4 50N5 51N5 56N5
100.0	-	110.0	(11)	4N4 18N3 21N1 33N2 36N3 38N1 40N4 49N3 51N1 51N2 56N4
110.0	-	120.0	(8)	7N5 18N5 21N2 33N3 38N5 51N4 56N1 62N3
120.0	-	130.0	(0)	
130.0	-	140.0	(0)	
140.0	-	150.0	(0)	
150.0	-	160.0	(0)	
160.0	-	170.0	(0)	
170.0	-	180.0	(1)	68N2

EODCAP 1

VARIABLE NO. 39 MANUFACTURERS TESTS NOT EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH) BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
4.90000	6.65000	1.75000	495	6.19738	.223111

4.900	-	5.000	(1)	62N4
5.000	-	5.100	(0)	
5.100	-	5.200	(1)	10N1
5.200	-	5.300	(0)	
5.300	-	5.400	(1)	18N4
5.400	-	5.500	(2)	28N2 31N3
5.500	-	5.600	(5)	13N3 43N1 43N4 62N3 62N5
5.600	-	5.700	(3)	13N5 43N3 48N3
5.700	-	5.800	(2)	28N4 57N3
5.800	-	5.900	(8)	10N3 13N4 28N3 31N4 31N5 38N3 43N5 48N4
5.900	-	6.000	(47)	4N1 4N2 7N1 7N2 10N2 10N5 13N1 13N2 18N2 28N1 28N5 31N1 31N2 43N2 48N5 52N3 57N4 62N2 65N1 65N2 65N3 65N6 66N1 66N2 66N3 66N4 67N1 67N2 67N3 67N4 67N6 67N7 67N8 68N1 68N2 68N3 69N1 69N2 69N3 70N1 70N2 70N3 71N1 71N2 71N3 72N1 72N2
6.000	-	6.100	(38)	8N3 8N4 8N5 26N3 34N3 34N4 36N5 37N3 37N4 37N5 38N1 51N5 52N5 55N3 55N4 57N1 59N5 65N4 65N5 65N7 65N8 66N5 66N6 66N8 67N5 68N4 68N5 68N6 68N7 68N8 69N4 69N6 70N4 73N6 76N3 76N8 81N7 87N3
6.100	-	6.200	(153)	1N4 1N5 2N2 4N3 6N3 7N5 9N1 9N2 9N3 9N4 9N5 11N4 12N3 12N4 12N5 14N2 14N3 15N3 15N4 15N5 16N4 18N1 19N1 19N2 20N2 20N5 21N1 21N2 23N1 23N3 23N5 24N2 25N3 26N4 26N5 27N4 29N3 29N5 30N1 30N2 32N1 32N2 32N3 32N4 33N1 33N2 33N4 34N5 35N1 36N4 38N2 38N4 39N1 39N2 41N3 41N5 42N1 44N1 44N2 44N3 46N3 47N1 47N2 48N1 49N1 49N2 49N3 50N2 51N1 51N2 51N4 52N4 53N2 54N4 54N5 55N5 56N1 56N2 56N3 57N2 57N5 58N2 60N2 61N1 61N2 61N3 61N4 61N5 62N1 63N1 66N7 69N5 69N7 69N8 71N4 71N6 71N7 71N8 72N3 72N6 72N8 73N1 73N4 73N5 73N7 73N8 74N2 74N3 74N5 74N6 74N7 75N1 75N3 75N7 76N1 76N5 76N6 76N7 81N1 81N2 81N4 81N5 81N6 81N8 82N1 82N2 82N3 82N4 82N5 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N4 84N5 84N6 84N7 84N8 85N3 85N4 85N5 85N6 85N7 85N8 86N1 86N3 86N4 87N1 87N2
6.200	-	6.300	(87)	2N1 5N2 6N4 6N5 11N1 11N2 11N5 14N1 14N4 14N5 16N1 16N3 17N5 19N5 23N2 23N4 24N1 24N4 25N1 25N2 27N1 27N2 27N3 27N5 29N4 32N5 33N3 33N5 34N1 35N2 38N5 40N1 40N2 40N4 40N5 41N4 44N4 44N5 45N1 45N2 47N3 47N4 47N5 49N4 49N5 50N1 51N3 54N3 56N5 58N1 58N3 58N4 58N5 60N1 63N2 70N5 70N6 70N7 70N8 71N5 72N4 72N5 72N7 73N2 73N3 74N1 74N4 74N8 75N2 75N4 75N5 75N6 75N8 77N2 77N3 77N6 77N8 78N2 78N4 78N6 78N7 78N8 83N2 83N3 85N1 85N2 86N6
6.300	-	6.400	(79)	2N3 2N4 2N5 3N1 3N3 3N4 3N5 4N5 5N1 5N3 5N5 8N1 8N2 11N3 16N2 16N5 17N1 17N2 17N3 17N4 19N3 19N4 20N1 20N3 22N2 22N3 22N4 22N5 24N3 24N5 34N2 35N3 35N4 35N5 36N1 37N1 37N2 39N3 39N4 40N3 42N2 50N3 50N4 50N5 52N1 53N3 53N4 54N1 54N2 76N2 76N4 77N1 77N4 77N5 77N7 78N1 78N3 78N5 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 83N1 86N2 86N5 86N7 86N8
6.400	-	6.500	(15)	1N3 3N2 5N4 7N3 20N4 22N1 36N2 39N5 46N5 52N2 53N5 55N1 55N2 59N3 59N4
6.500	-	6.600	(18)	1N1 1N2 6N1 15N2 18N4 21N4 26N1 29N2 36N3 41N1 41N2 46N1 46N2 46N4 48N2 56N4 63N3 63N4
6.600	-	6.700	(35)	4N4 6N2 7N4 12N1 12N2 15N1 18N3 18N5 21N3 21N5 25N4 25N5 26N2 29N1 30N3 30N4 30N5 42N3 42N4 42N5 45N3 45N4 45N5 53N1 59N1 59N2 60N3 60N4 60N5 63N5 64N1 64N2 64N3 64N4 64N5

EODCAP 2

VARIABLE NO. 40 MANUFACTURERS TESTS NO2 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
5.90000	7.10000	1.20000	495	5.73051	.172944

5.900	-	6.000	(1)	62N4
6.000	-	6.100	(1)	10N1
6.100	-	6.200	(4)	28N2 38N3 62N3 62N5
6.200	-	6.300	(2)	10N4 43N1
6.300	-	6.400	(6)	15N5 26N3 28N3 31N3 33N4 57N3
6.400	-	6.500	(14)	11N4 13N3 13N5 28N1 43N4 48N3 48N5 51N3 57N4 62N2 63N1 68N5 68N6 76N8
6.500	-	6.600	(54)	3N5 4N5 8N1 8N2 11N2 11N5 12N5 13N4 15N4 16N3 16N4 16N5 17N3 20N5 22N5 23N3 25N3 26N4 28N4 30N1 30N2 31N4 33N5 36N1 36N5 38N4 41N5 42N1 42N2 43N3 43N5 45N1 46N3 48N2 50N3 51N5 57N5 60N2 63N2 66N1 68N4 68N7 69N4 69N6 70N1 71N2 71N3 72N2 72N5 76N3 76N5 76N6 81N7 87N3
6.600	-	6.700	(154)	1N1 1N2 2N2 2N4 3N3 3N4 5N3 5N4 6N1 6N2 7N5 10N3 10N5 11N1 11N3 12N3 12N4 14N3 14N4 15N3 16N1 16N2 17N1 17N2 17N4 17N5 19N1 19N2 19N3 19N4 19N5 20N2 20N3 20N4 22N2 22N3 22N4 23N1 23N2 23N4 23N5 24N1 24N2 25N1 25N2 25N5 26N5 27N2 27N4 27N5 28N5 29N3 29N5 30N3 30N5 31N5 32N2 32N3 32N5 33N3 34N2 35N5 36N4 37N1 37N2 38N5 39N1 39N2 39N4 39N5 40N3 40N4 40N5 41N3 41N4 42N3 42N5 44N1 44N3 44N4 44N5 45N2 45N4 46N5 47N3 48N4 49N1 49N2 49N3 49N4 49N5 50N2 50N4 50N5 51N4 52N1 52N2 53N1 53N2 53N3 53N4 53N5 54N1 54N3 54N4 54N5 55N1 55N2 56N3 57N1 60N1 60N4 61N3 61N4 61N5 63N3 63N4 63N5 65N5 65N6 66N2 66N5 66N6 67N1 68N1 68N3 68N8 69N1 69N2 69N3 69N5 69N7 69N8 70N2 70N3 70N4 71N1 71N6 71N8 72N1 72N3 72N4 73N1 74N2 76N1 76N4 76N7 79N5 80N7 81N1 81N8 84N1 87N1 87N2
6.700	-	6.800	(52)	1N3 2N5 3N1 3N2 5N1 5N2 9N2 14N1 14N5 24N3 24N4 24N5 27N3 29N2 29N4 30N4 32N1 32N4 35N1 35N3 35N4 39N3 45N3 45N5 47N4 47N5 48N1 56N5 58N3 58N4 58N5 60N3 60N5 62N1 65N2 65N3 65N7 65N8 67N2 67N3 67N4 67N8 71N4 73N2 74N3 79N6 79N8 80N5 81N6 85N2 85N7 86N6
6.800	-	6.900	(106)	1N5 2N3 5N5 6N3 6N5 7N3 7N4 8N3 9N1 9N3 9N4 9N5 13N2 14N2 18N3 18N4 18N5 20N1 21N3 21N4 21N5 22N1 25N4 27N1 35N2 36N2 36N3 40N1 40N2 42N4 44N2 47N1 47N2 50N1 54N2 56N4 57N2 58N1 58N2 59N3 59N4 59N5 61N1 61N2 65N1 65N4 66N3 66N4 66N7 67N6 67N7 68N2 70N5 70N6 70N7 70N8 71N5 71N7 72N6 72N7 73N3 74N1 75N1 75N2 75N3 75N6 76N2 77N6 78N3 78N4 79N1 79N2 79N4 79N7 80N1 80N2 80N4 80N6 81N2 82N1 82N2 82N3 82N4 82N5 83N1 83N2 83N3 83N4 83N5 83N6 83N7 83N8 84N2 84N3 84N6 84N7 84N8 85N1 85N3 85N5 85N6 86N1 86N2 86N5 86N7 86N8
6.900	-	7.000	(68)	1N4 2N1 4N1 4N2 4N5 6N4 7N1 7N2 8N4 8N5 12N1 12N2 13N1 15N1 15N2 18N2 26N1 26N2 29N1 31N1 31N2 34N1 34N3 37N3 37N4 37N5 38N1 41N1 41N2 43N2 46N1 46N2 46N4 52N3 55N3 59N1 59N2 64N1 64N2 64N3 64N4 64N5 66N8 67N5 72N8 73N6 73N8 75N5 75N7 75N8 77N2 77N4 77N5 77N7 78N1 78N2 78N5 78N7 78N8 79N3 80N3 80N8 84N4 84N5 85N4 85N8 86N3 86N4
7.000	-	7.100	(28)	4N3 10N2 13N1 21N1 21N2 33N1 33N2 34N4 34N5 38N2 51N1 52N4 52N5 55N4 55N5 56N1 73N4 74N4 74N5 74N6 74N7 74N8 75N4 77N1 77N3 77N8 78N6 81N5
7.100	-	7.200	(5)	51N2 56N2 73N5 73N7 81N4

EODCAP 3

VARIABLE NO. 41 MANUFACTURERS TESTS NO3 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
5.69900	8.14900	2.45000	492	7.03610	.463860

5.600	-	5.800	(2)	75N6 76N8
5.800	-	6.000	(6)	26N3 76N1 76N3 76N4 76N5 76N7
6.000	-	6.200	(5)	15N5 33N4 46N3 62N4 76N2
6.200	-	6.400	(17)	4N5 10N1 10N4 12N5 26N4 28N2 33N5 36N1 38N3 38N4 41N5 43N1 51N3 62N3 62N5 66N5 66N6
6.400	-	6.600	(33)	7N5 12N3 12N4 13N3 13N5 15N3 15N4 28N3 29N3 31N3 33N3 38N5 41N3 41N4 43N3 48N3 51N4 57N3 62N2 65N6 65N8 69N8 73N8 74N4 74N5 74N6 74N7 74N8 75N1 75N6 79N5 81N5 81N7
6.600	-	6.800	(90)	10N3 13N4 26N5 28N1 28N4 28N5 29N2 31N4 31N5 36N5 38N1 43N4 43N5 48N4 48N5 51N5 57N4 57N5 65N4 65N5 65N7 66N4 66N7 67N4 67N7 67N8 68N4 68N6 68N7 69N4 69N7 70N1 70N5 70N7 71N1 71N2 71N3 71N4 71N6 71N8 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 73N1 73N2 73N3 73N6 73N7 74N1 74N2 75N2 75N3 75N8 77N1 77N4 77N5 77N6 77N7 79N1 79N2 79N3 79N4 79N6 79N8 80N4 80N7 80N8 81N1 81N2 81N4 81N6 81N8 82N1 82N2 82N3 85N2 85N3 85N5 85N7 86N6 86N7 86N8 87N1 87N2 87N3
6.800	-	7.000	(92)	2N2 4N1 7N2 7N3 10N5 12N1 12N2 13N2 15N1 15N2 26N1 26N2 29N1 29N4 29N5 31N1 35N1 36N2 36N4 41N1 41N2 43N2 46N1 46N2 46N4 48N1 49N1 54N5 56N3 56N5 57N1 59N1 59N2 59N3 59N4 62N1 64N1 64N2 64N3 64N5 66N8 67N5 67N6 68N3 68N5 68N8 69N1 69N2 69N3 69N5 69N6 70N2 70N3 70N4 70N6 70N8 71N5 71N7 73N4 73N5 74N3 75N7 77N2 77N8 78N1 78N3 78N4 78N5 78N8 80N1 80N2 80N3 80N5 80N6 82N4 82N5 83N2 83N4 83N6 83N8 84N1 84N3 84N6 84N7 85N1 85N6 85N8 86N1 86N2 86N3 86N4 86N5
7.000	-	7.200	(82)	1N3 2N1 2N4 4N2 4N4 5N1 5N2 5N5 7N1 7N4 10N2 13N1 18N1 18N2 18N3 18N4 18N5 20N1 20N2 20N5 21N3 21N4 21N5 22N4 23N1 23N2 23N5 31N2 33N1 35N2 35N4 36N3 38N2 39N5 40N1 40N2 40N4 40N5 46N5 48N2 49N2 49N3 49N5 50N3 50N4 50N5 51N1 53N4 53N5 54N1 54N2 54N3 54N4 56N4 57N2 59N5 64N4 65N1 65N2 65N3 66N1 66N2 66N3 67N1 67N2 67N3 68N1 68N2 75N4 75N5 77N3 78N2 78N6 78N7 79N7 83N3 83N5 83N7 84N2 84N4 84N5 84N8
7.200	-	7.400	(43)	2N3 2N5 4N3 5N3 5N4 6N3 11N1 11N3 11N4 11N5 20N3 20N4 21N1 21N2 22N3 23N3 23N4 25N5 30N2 30N5 33N2 35N3 35N5 39N2 40N3 42N1 42N2 42N3 45N4 45N5 49N4 50N1 50N2 51N2 53N2 53N3 56N1 56N2 60N3 60N4 60N5 63N1 83N1
7.400	-	7.600	(45)	1N1 1N2 1N4 1N5 6N1 6N2 6N4 8N1 8N2 9N1 11N2 14N1 14N2 16N1 16N2 16N3 17N1 19N5 25N1 25N2 25N4 27N1 27N2 30N1 30N3 30N4 32N1 39N3 42N4 42N5 44N4 45N1 45N2 45N3 47N3 52N2 53N1 60N1 60N2 61N1 63N2 63N3 63N4 63N5 85N4
7.600	-	7.800	(47)	3N3 3N4 3N5 6N5 8N3 8N4 9N2 14N3 14N4 14N5 17N2 17N3 17N4 17N5 19N1 19N2 19N3 19N4 22N1 22N5 24N1 24N2 24N3 27N3 27N4 27N5 32N3 32N4 32N5 34N2 37N1 37N2 39N1 44N3 44N5 47N1 47N4 47N5 52N1 55N1 55N2 55N5 58N3 58N4 58N5 61N4 61N5
7.800	-	8.000	(15)	9N3 9N4 9N5 22N2 32N2 34N1 44N1 44N2 47N2 52N3 55N3 58N1 58N2 61N2 61N3
8.000	-	8.200	(15)	3N1 3N2 8N5 24N4 24N5 34N3 34N4 34N5 37N3 37N4 37N5 39N4 52N4 52N5 55N4

EUDCAP 4 VARIABLE NO. 42 MANUFACTURERS TESTS NV4 EUD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH) BY PACK*CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
6.40000	8.64900	2.24900	491	7.81190	.478152

6.400	-	6.600	(4)	76N1 76N5 76N6 76N8
6.600	-	6.800	(4)	76N2 76N3 76N4 76N7
6.800	-	7.000	(4)	65N5 65N7 66N5 66N6
7.000	-	7.200	(60)	15N5 33N5 38N3 38N4 51N3 65N4 65N6 65N8 66N4 66N7 66N8 67N4 67N5 67N6 67N7 67N8 68N4 68N5 68N6 72N6 72N8 73N6 73N8 74N4 74N5 74N6 74N7 74N8 75N2 75N6 75N7 77N6 78N4 78N5 81N4 81N5 81N7 81N8 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N4 84N5 84N6 84N7 84N8 85N2 85N3 85N4 85N5 85N6 85N7 85N8 86N3 86N4 86N6
7.200	-	7.400	(56)	12N5 26N3 33N4 41N5 46N3 68N7 68N8 69N4 69N5 69N6 69N7 71N3 72N3 72N4 73N1 73N4 73N5 73N7 75N1 75N3 75N4 75N5 75N8 77N1 77N2 77N4 77N5 77N7 77N8 78N1 78N2 78N3 78N6 78N7 78N8 79N5 79N7 79N8 81N6 82N1 82N2 82N3 82N4 82N5 83N1 83N2 83N3 84N3 85N1 86N1 86N5 86N7 86N8 87N1 87N2 87N3
7.400	-	7.600	(48)	4N5 12N4 15N4 26N4 29N3 36N1 36N5 38N5 41N3 41N4 51N4 51N5 69N2 69N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N4 71N5 71N6 71N7 71N8 72N1 72N2 72N5 72N7 73N2 73N3 74N1 74N2 74N3 77N3 79N2 79N3 79N4 79N6 80N2 80N6 80N7 81N1 86N2
7.600	-	7.800	(28)	8N3 10N1 12N3 15N3 26N5 28N2 44N4 62N3 62N5 65N1 65N2 65N3 66N1 66N2 66N3 67N1 67N3 68N1 68N3 69N1 69N3 79N1 80N1 80N3 80N4 80N5 80N8 81N2
7.800	-	8.000	(50)	7N5 8N4 8N5 10N4 13N3 13N4 13N5 14N3 14N4 27N3 27N5 28N3 28N4 29N5 31N3 31N4 31N5 32N1 32N4 32N5 33N2 33N3 34N3 34N4 34N5 36N3 37N3 37N4 37N5 38N1 38N2 43N1 43N3 43N4 43N5 44N3 44N5 47N3 47N5 48N3 52N3 52N4 55N3 57N3 57N4 58N3 61N5 62N4 67N2 68N2
8.000	-	8.200	(93)	3N3 3N4 3N5 4N2 4N4 7N1 7N2 8N1 8N2 9N1 9N2 9N3 9N5 10N2 10N3 10N5 11N2 11N4 13N2 14N1 14N2 14N5 16N3 17N1 17N3 17N4 17N5 18N1 18N2 19N4 21N4 22N3 22N4 22N5 24N2 25N3 27N1 27N2 27N4 28N1 28N5 29N4 30N2 31N1 31N2 32N2 32N3 33N1 34N2 36N4 37N2 39N5 40N4 40N5 42N1 43N2 44N1 46N5 47N2 47N4 48N1 48N4 48N5 49N1 50N3 50N4 50N5 52N2 52N5 53N3 53N4 53N5 54N3 55N1 55N4 55N5 56N1 56N2 56N4 56N5 57N1 57N5 58N2 58N4 58N5 59N4 61N1 61N2 61N3 61N4 62N1 62N2 63N2
8.200	-	8.400	(122)	1N3 1N4 1N5 2N1 2N2 2N3 2N4 2N5 3N1 4N1 4N3 5N1 5N2 5N3 5N5 6N2 6N3 6N4 6N5 7N3 9N4 11N1 11N3 11N5 12N1 12N2 13N1 15N1 15N2 16N1 16N2 16N4 16N5 17N2 18N3 18N4 18N5 19N1 19N2 19N3 19N5 20N1 20N2 20N3 20N5 21N1 21N2 21N3 21N5 22N1 22N2 23N1 23N2 23N3 23N4 23N5 24N1 24N3 24N4 24N5 25N1 25N2 25N5 26N1 26N2 29N1 29N2 30N1 30N5 34N1 35N1 35N2 35N3 35N5 36N2 37N1 39N1 39N2 39N3 39N4 40N3 41N1 41N2 42N2 44N2 45N1 45N2 45N4 46N1 46N2 46N4 47N1 48N2 49N2 49N3 49N4 49N5 50N1 50N2 52N1 53N2 54N1 54N2 54N4 54N5 55N2 56N3 57N2 58N1 59N1 59N2 59N3 59N5 60N1 60N2 60N5 63N1 64N1 64N2 64N3 64N4 64N5
8.400	-	8.600	(17)	3N2 5N4 6N1 7N4 20N4 30N3 30N4 35N4 42N3 42N4 42N5 45N3 45N5 60N3 60N4 63N3 63N4
8.600	-	8.800	(5)	1N1 1N2 25N4 53N1 63N5

EODCAP 5

VARIABLE NO. 43 MANUFACTURERS TESTS NUS EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.60000	8.14900	6.54900	488	7.51745	.496124

1.200	-	1.800	(1)	37N5
1.800	-	2.400	(0)	
2.400	-	3.000	(0)	
3.000	-	3.600	(0)	
3.600	-	4.200	(0)	
4.200	-	4.800	(1)	61N3
4.800	-	5.400	(0)	
5.400	-	6.000	(0)	
6.000	-	6.600	(0)	
6.600	-	7.200	(154)	4N5 7N5 10N1 12N5 15N5 26N3 26N4 28N2 33N3 33N4 33N5 36N1 38N3 38N4 38N5 41N5 43N1 46N3 51N3 51N4 62N5 65N2 65N5 65N6 65N8 66N1 66N2 66N3 66N6 67N1 68N1 68N3 68N5 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 71N1 71N2 71N3 72N1 72N2 72N3 72N4 72N8 73N1 73N2 73N6 73N8 74N2 74N5 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 76N1 76N2 76N3 76N4 76N5 76N6 76N7 76N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N6 80N7 81N4 81N6 81N7 81N8 82N1 82N2 82N3 82N4 82N5 83N1 83N2 83N3 83N4 83N5 83N6 83N7 83N8 84N1 84N2 84N3 84N4 84N5 84N6 84N7 84N8 85N1 85N2 85N3 85N4 85N5 85N6 85N7 85N8 86N1 86N2 86N3 86N4 86N5 86N6 86N7 86N8 87N1 87N2 87N3
7.200	-	7.800	(118)	4N1 4N2 4N3 4N4 7N1 7N2 7N3 7N4 8N2 10N2 10N4 12N3 12N4 13N1 13N2 13N3 13N4 13N5 15N3 15N4 18N1 18N2 18N3 18N4 18N5 21N1 21N2 21N3 21N4 21N5 26N5 28N1 28N3 28N4 29N3 29N5 30N2 31N1 31N2 31N3 31N4 31N5 33N1 33N2 36N2 36N3 36N4 36N5 38N1 38N2 40N2 40N4 41N1 41N3 41N4 43N2 43N3 43N5 48N1 48N3 48N5 49N3 51N1 51N2 51N5 56N1 56N2 56N3 56N4 56N5 57N1 57N3 57N4 62N2 62N3 62N4 65N1 65N3 65N4 65N7 66N4 66N5 66N7 66N8 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N2 68N4 70N5 70N6 70N7 70N8 71N4 71N5 71N6 71N7 71N8 72N5 72N6 72N7 73N3 73N4 73N5 73N7 74N1 74N3 74N4 74N6 80N5 80N8 81N1 81N2 81N5
7.800	-	8.400	(214)	1N1 1N2 1N3 1N4 1N5 2N1 2N2 2N3 2N4 2N5 3N1 3N2 3N3 3N4 3N5 5N1 5N2 5N3 5N4 5N5 6N1 6N2 6N3 6N4 6N5 8N1 8N3 8N4 8N5 9N1 9N2 9N3 9N4 9N5 10N3 10N5 11N1 11N2 11N3 11N4 11N5 12N1 12N2 14N1 14N2 14N3 14N4 14N5 15N1 15N2 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 19N1 19N2 19N3 19N4 19N5 20N1 20N2 20N3 20N4 20N5 22N1 22N2 22N3 22N4 22N5 23N1 23N2 23N3 23N4 23N5 24N1 24N2 25N1 25N2 25N3 25N4 25N5 26N1 26N2 27N1 27N2 27N3 27N4 27N5 28N5 29N1 29N2 29N4 30N1 30N3 30N4 30N5 32N1 32N2 32N3 32N4 32N5 34N1 34N2 34N3 34N4 34N5 35N1 35N2 35N3 35N4 35N5 37N1 37N2 37N3 37N4 39N1 39N2 39N3 39N4 39N5 40N1 40N3 40N5 41N2 42N1 42N2 42N3 42N4 42N5 43N4 44N1 44N2 44N3 44N4 44N5 45N1 45N2 45N3 45N4 45N5 46N1 46N2 46N4 46N5 47N1 47N2 47N3 47N4 47N5 48N2 48N4 49N1 49N2 49N4 49N5 50N1 50N2 50N3 50N4 50N5 52N1 52N2 52N3 52N4 52N5 53N1 53N2 53N3 53N4 53N5 54N3 55N1 55N2 55N3 55N4 55N5 57N2 57N5 58N1 58N2 58N3 58N4 58N5 59N1 59N2 59N3 59N4 59N5 60N1 60N2 60N3 60N4 60N5 61N1 61N2 61N4 61N5 62N1 63N1 63N2 63N3 63N4 63N5 64N1 64N2 64N3 64N4 64N5

EODCAP 6

VARIABLE NO. 44 MANUFACTURERS TESTS NO6 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH) BY PACK&CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
5.90000	7.75000	1.85000	495	6.97916	.433774

5.900	-	6.000	(1)	15N3
6.000	-	6.100	(1)	76N4
6.100	-	6.200	(12)	26N3 74N4 76N1 76N3 76N5 76N6 76N7 76N8 77N5 77N6 79N5 79N7
6.200	-	6.300	(7)	26N4 74N5 76N2 77N1 77N2 80N2 85N3
6.300	-	6.400	(41)	10N1 12N3 12N5 15N4 29N5 48N1 57N1 73N8 74N6 74N7 74N8 77N4 77N7 77N8 79N2 79N4 81N4 81N6 81N7 81N8 83N4 83N5 83N6 83N7 83N8 84N4 84N5 84N6 84N7 84N8 85N4 85N5 85N6 85N7 85N8 86N3 86N4 86N6 86N7 87N1 87N2
6.400	-	6.500	(28)	12N4 15N5 28N2 29N3 41N3 41N5 46N3 46N5 57N2 59N3 62N1 62N5 77N3 79N1 79N3 79N6 79N8 80N1 80N3 80N6 80N7 80N8 81N5 82N1 82N2 83N1 86N5 86N8
6.500	-	6.600	(15)	13N3 26N5 28N3 29N4 41N4 59N4 59N5 72N6 80N4 80N5 82N3 82N4 83N2 83N3 87N3
6.600	-	6.700	(24)	10N4 43N3 57N3 57N4 62N3 62N4 66N5 66N6 72N7 72N8 73N7 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 78N7 78N8 82N5 84N1 85N2
6.700	-	6.800	(12)	31N5 43N1 56N2 66N7 70N2 70N3 73N4 73N5 73N6 78N1 85N1 86N1
6.800	-	6.900	(44)	4N5 12N1 13N4 13N5 15N2 18N1 21N4 26N1 26N2 29N1 29N2 31N3 33N1 33N2 33N4 36N1 38N1 38N2 38N4 41N2 48N5 51N1 51N2 56N1 62N2 64N3 64N4 65N5 65N7 65N8 66N8 68N4 69N3 71N1 71N2 71N3 72N1 72N3 78N3 78N4 78N5 84N2 84N3 86N2
6.900	-	7.000	(78)	4N2 4N3 4N4 6N5 7N2 7N3 7N5 10N2 10N3 10N5 12N2 13N2 15N1 18N2 18N3 21N1 21N2 21N5 28N1 28N4 31N1 31N2 31N4 33N3 33N5 34N4 34N5 36N2 38N3 41N1 43N2 43N4 46N1 46N4 48N3 48N4 50N1 51N3 51N4 54N4 57N5 59N1 59N2 64N1 64N2 64N5 65N1 65N2 65N4 65N6 66N3 66N4 67N1 67N5 67N6 67N7 67N8 68N5 68N6 68N7 68N8 69N1 69N2 69N7 69N8 70N1 70N4 70N8 71N8 72N2 72N4 73N1 73N2 73N3 74N2 78N2 78N6 81N1
7.000	-	7.100	(42)	1N4 1N5 3N1 4N1 5N2 6N4 7N1 7N4 13N1 18N4 18N5 20N1 21N3 23N1 28N5 36N3 38N5 43N5 46N2 56N4 56N5 65N3 66N1 66N2 67N2 67N3 67N4 68N1 68N2 68N3 69N4 69N5 69N6 70N5 70N6 71N4 71N6 71N7 72N5 74N1 74N3 81N2
7.100	-	7.200	(39)	1N2 2N1 2N2 3N2 5N1 6N3 11N1 11N2 16N1 16N2 19N1 19N2 20N2 22N2 23N2 24N1 24N2 25N2 30N1 30N2 35N1 35N2 36N4 36N5 39N1 39N2 40N1 40N2 42N2 45N1 45N2 49N1 49N2 51N5 53N2 54N2 56N3 70N7 71N5
7.200	-	7.300	(15)	6N1 11N3 11N4 11N5 22N1 25N1 42N1 48N2 50N2 53N1 54N1 54N5 60N1 60N2 63N1
7.300	-	7.400	(10)	1N1 6N2 17N1 17N2 17N4 20N3 24N5 40N4 49N3 49N5
7.400	-	7.500	(36)	2N3 2N4 2N5 5N3 5N4 5N5 17N5 19N3 20N4 20N5 22N3 22N4 23N3 23N4 23N5 24N3 24N4 34N1 35N4 35N5 37N1 37N2 39N3 39N4 40N3 40N5 42N3 42N4 44N2 47N1 49N4 52N1 54N3 55N2 60N3 60N5
7.500	-	7.600	(41)	1N3 3N3 3N5 8N5 9N5 14N5 16N3 16N5 17N3 19N4 19N5 22N5 25N3 25N4 25N5 30N3 30N4 30N5 34N2 34N3 35N3 39N5 45N3 45N5 47N2 50N4 50N5 52N2 52N4 52N5 53N5 55N1 55N4 55N5 58N1 60N4 61N3 63N2 63N3 63N4 63N5
7.600	-	7.700	(46)	3N4 8N1 8N2 9N1 9N2 9N3 9N4 14N1 14N2 14N3 14N4 16N4 27N1 27N2 27N3 27N4 27N5 32N1 32N2 32N3 32N4 32N5 37N3 37N4 37N5 42N5 44N1 44N3 44N4 44N5 45N4 47N3 47N4 47N5 50N3 53N3 53N4 55N3 58N2 58N3 58N4 58N5 61N1 61N2 61N4 61N5
7.700	-	7.800	(3)	8N3 8N4 52N3

EODCAP 7

VARIABLE NO. 45 MANUFACTURERS TESTS NO7 EOD CAPACITY (DISCH C/2 TO 1.0 VOLTS/CELL AH)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
5.69900	8.14900	2.45000	493	6.93273	.411151

5.600	-	5.800	(1)	26N3
5.800	-	6.000	(1)	26N4
6.000	-	6.200	(13)	12N5 29N3 33N5 38N3 38N4 41N4 51N3 66N5 66N6 75N1 75N2 81N6 81N8
6.200	-	6.400	(28)	12N4 15N4 15N5 27N3 36N5 41N3 51N4 51N5 75N3 75N5 75N6 75N7 75N8 77N4 77N5 79N2 79N5 79N7 79N8 81N7 82N1 82N2 82N3 82N4 82N5 87N1 87N2 87N3
6.400	-	6.600	(46)	8N2 10N1 10N5 13N4 28N2 28N3 28N4 31N5 33N4 38N5 41N5 43N1 43N2 46N3 48N3 57N3 62N4 70N1 71N1 71N2 71N3 72N2 72N6 72N8 73N5 73N8 74N4 74N5 74N6 74N7 74N8 75N4 77N1 77N2 79N1 79N3 79N4 79N6 80N2 81N4 81N5 84N1 85N1 85N2 85N4 86N1
6.600	-	6.800	(88)	3N3 3N4 3N5 4N5 8N1 10N2 10N3 13N2 13N3 13N5 15N3 17N3 22N5 26N5 28N1 29N4 29N5 31N1 31N4 32N5 34N1 34N2 36N1 43N4 43N5 44N4 48N1 48N5 53N5 55N1 57N1 57N4 58N3 61N3 62N1 62N2 62N3 62N5 65N7 66N3 69N1 69N2 69N3 70N2 70N3 72N1 72N3 72N5 72N7 73N1 73N2 73N4 73N5 73N7 74N1 74N2 77N3 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N7 78N8 80N1 80N3 80N4 80N5 80N6 80N7 80N8 81N1 81N2 83N4 83N8 84N2 84N3 84N7 85N3 85N5 85N6 85N7 86N2 86N4 86N6
6.800	-	7.000	(114)	5N5 7N5 8N3 8N4 9N1 9N3 10N4 12N3 13N1 14N3 14N4 16N3 17N1 17N2 17N4 17N5 19N3 19N4 22N2 22N3 22N4 23N5 25N5 27N2 27N4 27N5 30N5 31N2 31N3 32N1 33N3 34N3 36N3 36N4 37N1 37N2 37N5 42N3 43N2 44N1 44N3 45N3 45N4 45N5 47N3 48N4 50N3 50N5 52N1 52N2 54N4 55N2 55N3 56N3 56N4 56N5 57N2 57N5 59N4 60N3 60N4 60N5 61N4 61N5 63N3 63N4 65N1 65N2 65N3 65N5 65N8 66N1 66N2 66N3 66N4 67N1 67N3 67N6 67N7 68N1 68N5 68N7 69N6 69N7 69N8 70N7 70N8 71N4 71N5 71N6 73N3 74N3 76N1 76N3 76N4 76N5 76N6 76N8 78N6 83N1 83N2 83N3 83N5 83N6 83N7 84N4 84N5 84N6 84N8 85N8 86N3 86N5 86N7 86N8
7.000	-	7.200	(84)	1N3 3N1 3N2 6N2 7N3 8N5 9N2 9N4 9N5 11N2 11N4 11N5 14N1 14N2 14N5 16N5 18N3 19N1 19N5 20N3 21N4 22N1 24N2 24N4 25N3 25N4 27N1 30N3 30N4 32N2 32N3 32N4 34N4 35N4 36N2 37N3 37N4 38N1 39N3 39N4 39N5 40N4 42N4 42N5 44N5 47N2 47N4 47N5 48N2 50N4 52N3 52N4 53N2 53N3 53N4 56N1 59N2 58N4 58N5 59N3 59N5 61N1 61N2 63N2 63N5 65N4 65N6 66N7 66N8 67N2 67N4 67N5 67N8 68N2 68N4 68N6 68N8 70N4 70N5 70N6 71N7 71N8 76N2 76N7
7.200	-	7.400	(36)	6N1 6N4 7N2 16N4 18N5 19N2 20N5 23N4 24N1 24N3 24N5 25N1 28N5 33N1 33N2 34N5 35N5 39N1 39N2 40N5 42N1 42N2 44N2 45N2 47N1 50N1 50N2 51N1 52N5 55N4 55N5 60N1 63N1 69N4 69N5 72N4
7.400	-	7.600	(56)	1N1 1N2 1N4 1N5 2N3 2N4 2N5 4N1 4N4 5N3 5N4 6N3 6N5 7N1 11N1 11N3 12N1 12N2 15N1 15N2 16N1 16N2 18N4 20N4 21N1 21N2 21N3 21N5 23N3 25N2 26N2 29N1 30N1 30N2 35N3 38N2 40N3 41N1 41N2 45N1 46N1 46N2 46N5 49N4 49N5 51N2 53N1 54N3 56N1 59N1 59N2 60N2 64N1 64N3 64N4 64N5
7.600	-	7.800	(14)	4N2 4N3 7N4 26N1 29N2 35N1 35N2 40N1 40N2 46N4 49N2 54N1 56N2 64N2
7.800	-	8.000	(6)	2N1 23N2 49N1 49N3 54N2 54N5
8.000	-	8.200	(6)	2N2 5N1 5N2 20N1 20N2 23N1

TEST8

VARIABLE NO. 46 MANUFACTURERS TESTS NOR SHORT TEST (OPEN CIRCUIT VOLTAGE)
BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.11600	1.23200	.116000	492	1.19953	.164024E-01

1.110	-	1.120	(1)	36N5
1.120	-	1.130	(1)	54N4
1.130	-	1.140	(1)	5N2
1.140	-	1.150	(0)	
1.150	-	1.160	(3)	5N1 20N1 20N2
1.160	-	1.170	(7)	4N5 33N2 36N1 46N5 49N1 49N2 54N5
1.170	-	1.180	(47)	2N3 4N1 4N2 4N3 5N3 5N4 5N6 7N1 7N4 10N2 10N5 12N5 13N4 18N4 20N4 20N5 23N3 23N4 28N1 28N2 31N1 31N2 33N4 35N1 35N2 35N3 38N2 38N3 38N5 40N3 40N5 41N5 43N2 46N3 48N2 48N5 49N4 49N5 51N3 51N4 51N5 54N1 57N3 62N2 62N3 82N2 82N5
1.180	-	1.190	(72)	2N4 2N5 4N4 7N2 7N3 7N5 10N1 10N4 12N1 12N2 12N3 13N3 13N5 15N1 15N4 15N5 18N1 18N2 18N3 21N1 21N2 21N3 21N4 21N5 26N1 28N4 28N5 29N2 29N3 29N5 31N4 33N1 33N5 35N4 36N2 36N3 36N4 38N1 38N4 40N4 41N1 41N2 41N3 43N4 43N5 46N1 46N2 48N3 49N3 51N1 51N2 54N2 56N1 56N2 56N3 56N4 56N5 57N5 59N1 59N2 59N4 62N4 62N5 64N1 64N4 64N5 82N1 82N3 82N4 85N1 85N2 85N6
1.190	-	1.200	(98)	11N2 11N4 15N2 15N3 16N1 16N2 16N5 18N5 20N3 25N1 25N2 25N3 25N4 25N5 26N2 26N3 26N5 28N3 29N1 29N4 30N1 30N3 30N4 30N5 31N3 31N5 33N3 35N5 41N4 42N1 42N3 42N4 42N5 43N1 45N3 45N4 45N5 46N4 48N1 48N4 57N2 57N4 59N3 59N5 60N1 60N2 60N3 60N4 60N5 63N1 63N2 64N2 64N3 65N4 66N4 74N7 74N8 75N1 75N2 75N4 75N5 75N7 75N8 76N2 76N4 77N2 77N6 77N8 79N1 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N7 83N3 83N4 83N5 83N6 83N8 84N3 84N4 84N7 85N3 85N5 85N7 85N8 86N1 86N2 86N3 86N4 86N5 86N6 86N7 86N8
1.200	-	1.210	(134)	1N1 1N2 1N4 1N5 6N1 6N2 6N3 6N4 9N1 9N2 9N5 11N1 11N3 11N5 12N4 14N1 14N2 14N3 14N4 14N5 16N3 16N4 19N1 19N2 19N4 19N5 23N1 23N8 24N1 24N2 24N3 24N5 26N4 27N1 27N2 27N3 27N4 27N5 30N2 32N2 32N3 32N4 32N5 39N1 39N2 39N3 39N4 42N2 43N3 44N1 44N3 44N4 44N5 45N1 45N2 47N3 47N4 47N5 50N2 53N1 53N2 57N1 58N3 58N4 58N5 61N1 61N4 61N5 62N1 63N3 63N4 63N5 65N5 65N6 65N7 65N8 66N7 66N8 67N4 67N5 67N6 67N7 67N8 68N4 68N5 68N6 68N7 68N8 69N4 69N5 69N6 69N7 69N8 70N4 70N5 70N6 70N7 70N8 71N4 71N5 71N7 72N4 74N4 75N3 75N6 76N1 76N3 76N5 76N6 76N7 76N8 77N1 77N3 77N4 77N5 77N7 79N2 79N3 79N4 79N5 79N6 79N7 79N8 81N6 81N8 83N1 83N2 83N7 84N1 84N2 84N5 84N6 84N8 85N4
1.210	-	1.220	(69)	1N3 2N1 2N2 6N5 8N3 8N4 9N3 9N4 19N3 23N2 24N4 32N1 34N3 39N5 44N2 47N1 47N2 50N1 50N3 50N5 52N3 55N3 56N1 56N2 61N2 61N3 65N1 65N2 65N3 66N1 66N2 66N3 66N5 66N6 68N1 68N3 69N1 69N2 69N3 70N1 70N2 70N3 71N1 71N2 71N6 71N8 72N1 72N2 72N3 72N6 72N8 73N3 73N5 73N6 73N8 74N5 74N6 76N1 76N2 76N3 76N4 76N5 76N7 78N8 81N4 81N5 87N2 87N3
1.220	-	1.230	(57)	3N1 3N3 3N4 3N5 8N1 8N2 8N5 10N3 17N1 17N2 17N3 17N4 17N5 22N2 22N3 22N4 22N5 34N1 34N2 34N4 34N5 37N1 37N2 37N3 37N4 37N5 40N1 40N2 50N4 52N1 52N2 52N4 52N5 53N3 53N4 53N5 55N1 55N2 55N4 55N5 67N1 67N2 67N3 68N2 71N3 72N5 72N7 73N1 73N2 73N4 73N7 74N1 74N2 74N3 81N1 81N2 87N1
1.230	-	1.240	(2)	3N2 22N1

TEST9

VARIABLE NO. 47 MANUFACTURERS TESTS NOV INTERNAL RESISTANCE (DISCH C/2 FOR 1 HR) BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.17100	1.26600	.950000E-01	493	1.24733	.117362E-01

1.170	-	1.179	(4)	7N3 18N5 36N2 77N6
1.179	-	1.188	(1)	66N7
1.188	-	1.197	(0)	
1.197	-	1.206	(2)	4N4 75N4
1.206	-	1.215	(3)	18N3 75N5 75N8
1.215	-	1.224	(9)	4N5 7N4 36N1 36N3 51N4 56N4 65N7 75N7 76N5
1.224	-	1.233	(18)	7N5 21N3 36N5 38N3 38N4 43N2 51N3 51N5 70N8 75N1 75N6 77N2 77N3 80N8 81N7 83N4 83N8 85N3
1.233	-	1.242	(55)	18N4 21N2 26N5 29N5 33N5 36N4 38N5 41N2 41N3 41N4 41N5 46N3 46N5 49N4 56N3 59N3 59N5 62N1 65N5 65N8 66N8 68N5 70N6 71N4 75N3 76N1 76N2 76N3 76N4 76N6 76N7 76N8 77N1 77N4 79N2 79N3 79N4 79N5 79N7 80N1 80N2 80N5 80N6 83N1 84N6 84N8 85N1 85N2 85N6 85N7 86N1 86N2 86N3 86N7 86N8
1.242	-	1.251	(208)	2N3 2N4 2N5 4N3 5N3 5N4 5N5 7N1 10N2 10N4 10N5 12N1 12N2 12N4 12N5 13N3 13N4 13N5 14N3 14N4 15N1 15N3 15N4 15N5 16N3 16N5 18N1 18N2 20N3 20N4 20N5 21N4 23N3 23N4 25N3 25N4 25N5 26N1 26N2 26N3 26N4 26N5 27N5 28N4 29N1 29N2 29N3 29N4 30N3 30N4 30N5 31N2 31N3 31N4 31N5 32N3 33N2 33N3 33N4 35N3 35N4 35N5 38N1 40N3 40N4 40N5 41N1 42N3 42N4 42N5 43N5 44N3 45N3 45N4 45N5 46N1 46N2 47N5 48N1 48N2 48N3 48N4 48N5 49N3 49N5 51N1 54N3 54N5 56N5 57N1 57N2 57N3 57N4 57N5 58N3 58N4 58N5 59N1 59N2 59N4 60N3 60N4 60N5 61N4 61N5 63N2 63N3 64N1 64N2 64N3 64N4 64N5 65N1 65N2 65N4 65N6 66N3 66N4 67N1 67N2 67N4 67N5 67N6 67N7 67N8 68N3 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 70N5 70N7 71N1 71N2 71N3 71N5 71N7 72N1 72N2 72N4 72N5 72N6 73N5 73N6 73N8 74N4 74N5 74N6 74N7 74N8 75N2 77N5 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N1 79N6 79N8 80N3 80N4 80N7 81N1 81N4 81N5 81N6 81N8 82N1 82N2 82N3 82N4 82N5 83N2 83N3 83N5 83N6 83N7 84N1 84N2 84N3 84N4 84N5 84N7 85N4 85N5 85N8 86N4 86N5 86N6 87N2 87N3
1.251	-	1.260	(176)	1N1 1N2 1N3 1N4 1N5 2N1 2N2 3N3 3N5 4N1 4N2 5N1 5N2 6N1 6N2 6N3 6N4 6N5 7N2 8N1 8N2 8N3 8N4 8N5 9N1 9N2 9N3 9N4 9N5 10N1 10N3 11N1 11N2 11N3 11N4 11N5 12N3 14N1 14N2 14N5 15N2 16N1 16N2 16N4 17N3 17N4 17N5 19N1 19N2 19N3 19N4 19N5 20N1 20N2 21N1 21N5 22N3 22N4 22N5 23N1 23N2 23N5 24N1 24N2 24N3 24N4 24N5 25N1 25N2 27N1 27N2 27N3 27N4 28N1 28N2 28N3 30N1 30N2 31N1 32N1 32N2 32N4 32N5 33N1 34N3 34N4 34N5 35N1 35N2 37N3 37N4 37N5 38N2 39N1 39N2 39N3 39N4 39N5 40N1 40N2 42N1 42N2 43N1 43N4 44N1 44N2 44N4 44N5 45N1 45N2 46N4 47N1 47N2 47N3 47N4 49N1 49N2 50N1 50N2 50N3 50N4 50N5 51N2 52N3 52N4 52N5 53N1 53N2 53N4 54N1 54N2 54N4 55N1 55N3 55N4 55N5 56N1 56N2 58N1 58N2 60N1 60N2 61N1 61N2 61N3 62N2 62N3 62N4 62N5 63N1 63N4 63N5 65N3 66N1 66N2 66N5 66N6 67N3 68N1 68N2 68N4 71N6 71N8 72N3 72N7 72N8 73N1 73N2 73N3 73N4 73N7 74N1 74N2 74N3 81N2 87N1
1.260	-	1.269	(17)	3N1 3N2 3N4 17N1 17N2 22N1 22N2 34N1 34N2 37N1 37N2 43N3 52N1 52N2 53N3 53N5 55N2

TESTY

VARIABLE NO. 48 MANUFACTURERS TESTS NOW INTERNAL RESISTANCE (DISCH C/3.33 FOR 5 MIN) BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.03100	1.19500	.164000	493	1.13854	.197362E-01

1.030	-	1.040	(1)	64N3
1.040	-	1.050	(0)	
1.050	-	1.060	(1)	54N2
1.060	-	1.070	(1)	26N1
1.070	-	1.080	(0)	
1.080	-	1.090	(3)	12N2 64N1 64N4
1.090	-	1.100	(0)	
1.100	-	1.110	(23)	2N2 3N5 5N2 12N1 15N2 17N3 17N5 21N5 26N2 29N1 35N1 40N2 41N4 49N2 54N5 61N3 64N5 65N4 67N7 69N5 79N3 79N7 79N8
1.110	-	1.120	(42)	2N1 5N1 8N1 8N2 14N3 15N1 20N1 20N2 22N4 22N5 23N1 26N5 29N2 29N5 32N2 33N5 34N3 35N2 37N4 40N1 41N1 41N2 46N1 46N2 46N4 48N1 49N1 51N4 54N4 57N2 58N5 59N1 59N2 59N4 65N5 65N8 67N4 68N5 69N7 70N8 71N7 79N6
1.120	-	1.130	(79)	3N3 3N4 7N4 8N3 8N4 8N5 9N1 9N2 12N3 12N4 12N5 14N1 14N2 15N3 15N5 17N1 17N2 18N2 19N1 22N2 22N3 23N2 26N3 27N1 27N2 27N4 29N3 29N4 32N3 33N3 34N1 34N2 34N4 34N5 36N4 36N5 37N1 37N2 37N3 37N5 39N3 41N3 44N1 44N3 44N4 44N5 46N3 47N3 47N5 51N3 51N5 52N1 52N2 52N3 52N4 54N1 55N1 55N2 55N3 55N4 55N5 56N3 58N3 58N4 59N3 61N1 61N2 61N4 61N5 67N1 67N8 68N1 68N7 69N8 70N5 73N4 82N1 82N3 84N6
1.130	-	1.140	(87)	3N1 3N2 4N1 6N3 6N4 6N5 7N1 7N5 9N3 9N4 9N5 11N2 11N3 11N5 14N4 14N5 15N4 16N2 16N3 16N4 16N5 18N4 19N2 19N3 19N4 19N5 21N3 21N4 22N1 24N1 24N2 24N4 24N5 25N2 25N3 25N5 26N4 27N3 27N5 30N3 32N1 32N4 32N5 38N3 38N4 38N5 39N1 39N2 39N4 41N5 42N1 44N2 45N4 45N5 46N5 47N1 47N2 47N4 50N1 50N2 51N1 52N5 53N1 56N2 57N1 58N1 58N2 59N5 60N3 63N1 63N2 65N6 67N6 68N3 68N4 69N1 69N3 69N6 70N2 71N6 72N4 73N6 80N5 80N6 82N2 82N4 82N5
1.140	-	1.150	(131)	1N1 1N2 1N3 1N4 1N5 2N3 2N5 4N3 5N3 5N5 6N1 6N2 10N2 10N5 11N1 11N4 13N3 13N5 16N1 17N4 18N1 18N3 18N5 20N5 21N1 23N3 24N3 25N1 25N4 28N5 30N1 30N2 30N4 30N5 31N1 31N2 31N3 31N4 31N5 33N1 33N4 36N3 38N2 39N5 40N3 42N2 42N3 42N4 42N5 43N5 45N1 45N2 45N3 48N2 48N3 48N4 48N5 49N4 49N5 50N3 51N2 53N2 54N3 56N1 56N4 56N5 57N3 57N4 60N1 60N4 60N5 62N1 63N3 63N4 63N5 65N1 65N2 65N3 66N1 66N2 66N3 66N4 67N2 67N3 67N5 68N2 68N6 68N8 69N2 69N4 70N1 70N3 70N4 70N7 71N1 71N2 71N3 71N4 71N8 72N1 72N2 73N2 77N5 79N2 79N4 79N5 83N1 83N2 83N3 83N4 83N5 83N7 84N1 84N2 84N3 84N4 84N7 84N8 85N1 85N2 85N3 85N6 85N7 85N8 86N1 86N2 86N3 86N4 86N5 86N6 86N8
1.150	-	1.160	(83)	2N4 4N2 4N4 4N5 5N4 7N2 7N3 10N1 10N3 10N4 13N4 20N3 20N4 21N2 23N4 23N5 28N1 28N2 28N3 28N4 33N2 35N3 35N4 35N5 36N1 36N2 38N1 40N4 40N5 43N1 43N2 43N3 43N4 49N3 50N4 50N5 53N3 53N4 53N5 54N2 57N5 60N2 62N2 62N3 62N4 62N5 65N7 70N6 71N5 75N1 75N2 75N3 75N4 75N5 75N6 75N7 76N1 76N2 77N1 77N4 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 79N1 80N1 80N2 80N3 80N4 80N7 80N8 81N5 83N6 83N8 84N5 85N4 85N5 86N7
1.160	-	1.170	(13)	66N6 66N7 66N8 72N8 74N1 74N4 74N6 74N7 75N8 77N2 77N3 77N6 78N8
1.170	-	1.180	(13)	72N3 72N6 73N1 73N3 73N5 73N7 73N8 76N3 76N4 76N5 76N6 76N7 76N8
1.180	-	1.190	(14)	66N5 72N7 74N2 74N3 74N5 74N8 81N2 81N4 81N6 81N7 81N8 87N1 87N2 87N3
1.190	-	1.200	(2)	72N5 81N1

EOCTEST1

VARIABLE NO. 49 BASELINE TESTS NO 1 EOC VOLTAGE (CHG C/20 40HR 20 DEGREES C)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.37500	1.51200	.137000	460	1.43711	.193724E-01

1.370	- 1.380	(5)	64N1 64N2 64N3 64N4 64N5	
1.380	- 1.390	(10)	43N1 43N2 43N3 43N4 43N5 60N1 60N2 60N3 60N4 60N5	
1.390	- 1.400	(8)	47N1 47N2 47N3 47N4 47N5 56N1 56N2 56N4	
1.400	- 1.410	(14)	4N3 4N4 5N3 29N1 29N2 29N3 29N4 29N5 39N4 52N1 52N3 52N5 56N3 56N5	
1.410	- 1.420	(52)	4N1 4N2 4N5 5N1 5N2 5N4 5N5 7N1 7N2 7N4 7N5 8N1 8N4 10N1 10N2 10N3 10N4 10N5 14N1 14N2 14N3 14N4 14N5 19N1 19N2 19N3 19N4 19N5 23N1 23N2 23N3 23N4 23N5 25N1 25N2 25N3 25N4 25N5 35N1 35N2 35N3 35N4 35N5 39N2 39N3 39N5 52N2 52N4 58N1 58N2 58N3 58N5	
1.420	- 1.430	(27)	1N3 7N3 8N2 8N3 8N5 20N5 39N1 41N1 41N2 45N1 45N2 45N3 45N4 45N5 48N5 51N1 51N2 51N3 51N4 51N5 53N3 54N5 58N4 62N2 62N3 62N4 62N5	
1.430	- 1.440	(81)	1N2 1N4 2N3 2N4 9N4 11N1 11N2 11N3 11N4 11N5 13N1 13N3 13N4 13N5 15N1 15N2 15N3 15N4 15N5 19N1 18N4 18N5 20N1 20N2 20N3 20N4 21N2 21N3 26N2 28N1 28N2 28N3 28N4 28N5 31N3 31N4 31N5 33N1 33N2 38N1 38N2 38N3 38N4 38N5 41N3 41N4 41N5 44N1 44N2 44N3 44N4 44N5 48N3 48N4 49N1 49N2 49N3 49N5 50N5 54N1 54N2 54N3 57N3 57N4 57N5 61N2 62N1 67N5 67N8 68N5 68N7 74N2 74N3 76N1 76N2 76N3 76N4 76N5 76N6 76N7 76N8	
1.440	- 1.450	(150)	1N1 1N5 2N1 2N2 2N5 3N4 3N5 9N1 9N2 9N3 9N5 13N2 16N2 16N3 16N4 16N5 17N3 18N2 18N3 21N1 21N4 21N5 22N2 22N3 22N4 22N5 24N1 24N2 24N4 26N1 26N3 26N4 26N5 27N1 27N2 27N3 27N4 27N5 30N1 30N2 30N3 30N4 30N5 31N1 31N2 32N1 32N2 32N3 32N4 32N5 33N3 33N4 33N5 36N2 36N3 37N1 37N2 40N1 40N3 40N4 40N5 46N1 46N4 48N1 50N1 50N2 53N1 53N2 55N1 55N2 55N3 57N1 57N2 59N1 59N2 59N3 59N4 59N5 61N1 61N3 61N4 61N5 63N2 63N3 63N4 63N5 65N1 65N2 66N7 66N8 67N1 67N2 67N3 67N4 67N6 67N7 68N1 68N3 68N4 68N6 69N3 69N4 69N5 69N6 69N7 69N8 70N4 70N5 70N6 70N7 71N2 71N4 71N5 71N6 71N7 71N8 72N3 72N4 72N5 72N6 73N2 73N4 73N6 74N1 74N4 74N5 74N6 74N7 74N8 78N2 78N4 78N5 78N6 78N7 8N8 79N3 80N5 80N6 80N7 81N1 81N2 81N3 81N5 81N6 81N7 81N8 82N1 82N2 82N4 82N5	
1.450	- 1.460	(105)	3N1 3N2 3N3 6N1 6N2 6N3 6N4 6N5 16N1 17N1 17N2 17N4 17N5 22N1 24N3 24N5 34N1 34N2 34N3 34N4 34N5 36N1 36N4 36N5 37N3 37N4 37N5 40N2 46N2 46N3 46N5 48N2 49N4 50N3 50N4 53N4 53N5 54N4 55N4 55N5 63N1 65N3 65N4 65N5 65N6 65N7 65N8 66N1 66N4 66N5 66N6 68N2 68N8 69N1 69N2 70N1 70N2 70N3 70N8 71N1 71N3 72N1 72N2 72N7 72N8 73N1 73N3 73N5 73N7 73N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N3 79N1 79N2 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N8 81N4 82N3 96N1 96N3 96N4	
1.460	- 1.470	(3)	66N2 66N3 96N2	
1.470	- 1.480	(0)		
1.480	- 1.490	(0)		
1.490	- 1.500	(0)		
1.500	- 1.510	(3)	12N1 12N2 12N3	
1.510	- 1.520	(2)	12N4 12N5	

EOCTEST2

VARIABLE NO. 50 BASELINE TESTS NO 2 EOC VOLTAGE (CHG C/10 16HR 20 DEGREES C) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.38300	1.47900	.960000E-01	455	1.45246	.140695E-01

1.377	-	1.386	(1)	2N2
1.386	-	1.395	(4)	2N1 2N3 2N4 2N5
1.395	-	1.404	(0)	
1.404	-	1.413	(2)	56N1 56N2
1.413	-	1.422	(8)	25N1 25N2 25N3 25N4 41N1 41N2 56N3 56N4
1.422	-	1.431	(34)	9N1 9N2 9N3 9N4 9N5 22N1 25N5 32N1 35N1 35N4 36N4 36N5 41N3 41N4 41N5 43N1 43N3 43N4 43N5 45N1 45N2 45N3 45N4 45N5 56N5 58N1 62N2 62N3 62N4 62N5 64N2 64N3 64N4 64N5
1.431	-	1.440	(23)	22N2 22N3 22N4 22N5 23N5 32N2 32N3 32N4 32N5 34N4 35N3 35N5 36N2 36N3 39N4 43N2 52N5 53N3 58N2 58N3 58N4 58N5 64N1
1.440	-	1.449	(54)	10N1 10N3 10N4 10N5 13N3 20N2 20N5 23N1 23N2 23N3 23N4 28N1 28N2 28N3 28N4 28N5 31N4 34N3 34N5 35N2 36N1 39N2 39N3 39N5 48N3 48N4 48N5 49N1 49N2 49N3 49N5 52N1 52N2 52N3 52N4 54N5 57N3 60N1 60N2 60N3 60N4 60N5 62N1 69N4 69N5 69N6 69N7 81N1 81N2 81N4 81N5 81N6 81N7 81N8
1.449	-	1.458	(126)	4N1 4N2 4N3 4N4 5N1 5N2 6N2 7N3 7N4 8N1 8N2 10N2 13N1 13N2 13N4 13N5 14N1 14N2 14N3 14N4 14N5 18N1 18N5 19N1 19N2 19N4 20N3 20N4 24N2 24N4 26N1 26N2 26N3 26N5 27N2 27N3 27N4 27N5 29N1 29N2 29N3 29N5 31N3 31N5 33N1 33N2 34N1 34N2 38N1 38N2 38N3 38N4 38N5 39N1 44N1 44N2 44N3 44N4 44N5 48N1 50N5 53N2 54N1 54N2 54N3 55N1 55N3 57N1 57N4 57N5 59N1 59N2 59N3 59N4 59N5 61N1 61N2 61N3 61N4 61N5 63N4 65N1 65N2 65N4 65N5 65N6 65N7 65N8 67N4 67N5 67N6 67N7 67N8 68N1 68N5 68N7 69N1 69N2 69N3 69N8 71N4 71N5 71N6 71N7 71N8 73N2 73N4 73N6 74N1 74N2 74N3 76N1 76N2 76N3 76N4 76N5 76N6 76N7 76N8 79N3 81N3 82N1 82N2 82N3 82N4 82N5
1.458	-	1.467	(170)	1N3 3N1 3N2 3N3 3N4 3N5 4N5 5N3 5N4 5N5 6N1 6N3 6N4 6N5 7N1 7N2 7N5 8N3 8N4 8N5 11N1 11N2 11N3 11N4 11N5 12N4 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 18N2 18N3 18N4 19N3 19N5 20N1 21N1 21N2 21N3 21N4 21N5 24N1 24N3 24N5 24N4 27N1 29N4 30N1 30N2 30N3 30N4 30N5 31N1 31N2 33N3 33N4 33N5 37N1 37N2 37N3 37N4 37N5 40N1 40N3 40N4 40N5 46N1 46N2 46N3 46N4 46N5 49N4 50N1 50N2 50N3 50N4 51N1 53N1 53N4 53N5 54N4 55N2 55N4 55N5 57N2 63N2 63N3 63N5 65N3 66N1 66N4 66N5 66N7 66N8 67N1 67N2 67N3 68N3 68N4 68N6 68N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 73N1 73N3 73N5 73N7 73N8 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N4 75N7 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N1 79N2 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 96N4
1.467	-	1.476	(30)	1N1 1N2 1N4 1N5 12N1 12N2 12N3 12N5 15N1 15N2 15N3 15N4 15N5 16N1 40N2 48N2 51N2 51N3 51N4 51N5 63N1 66N5 68N2 71N3 75N3 75N5 75N6 75N8 96N2 96N3
1.476	-	1.485	(3)	66N2 66N3 96N1

EOCTEST3

BASELINE TESTS NO 3 EOC VOLTAGE (CHG C/40 20MR 20 DEGREES C)

VARIABLE NO. 51 BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.35400	1.38700	.330000E-01	455	1.37173	.635004E-02

1.353	-	1.356	(4)	11N1 41N1 41N2 62N4
1.356	-	1.359	(12)	41N3 41N4 45N3 56N1 56N2 56N3 56N4 56N5 62N1 62N2 62N3 62N5
1.359	-	1.362	(18)	1N3 11N2 33N1 33N2 41N5 45N1 45N2 45N4 45N5 46N1 46N2 46N3 46N4 46N5 48N1 48N3 48N4 48N5
1.362	-	1.365	(22)	1N2 1N4 18N1 18N3 18N4 18N5 21N5 33N3 33N4 35N1 35N2 35N3 35N4 35N5 48N2 51N1 51N2 52N2 82N1 82N2 82N3 82N5
1.365	-	1.368	(33)	1N1 1N5 2N3 2N5 5N1 5N2 5N3 5N4 5N5 10N1 10N4 11N3 11N4 11N5 15N1 15N2 15N3 18N2 33N5 36N1 36N2 36N3 39N2 39N4 51N3 51N4 51N5 52N1 52N3 52N5 65N8 76N8 82N4
1.368	-	1.371	(64)	2N1 2N2 2N4 4N1 4N2 4N3 4N4 4N5 6N1 7N1 7N5 9N1 9N2 10N3 10N5 12N2 13N1 13N3 13N4 13N5 14N3 14N4 14N5 15N4 15N5 19N1 19N2 19N3 19N4 21N1 21N2 21N3 21N4 23N1 23N2 23N3 23N4 23N5 25N2 25N4 25N5 26N1 26N2 26N4 26N5 28N4 29N2 29N3 30N2 36N4 36N5 39N1 39N3 52N4 54N1 54N2 54N3 76N1 76N2 76N3 76N4 76N5 76N6 76N7
1.371	-	1.374	(101)	3N3 3N4 3N5 6N2 6N3 6N4 6N5 7N2 7N3 7N4 8N1 8N2 8N3 8N4 9N3 9N4 9N5 10N2 12N1 12N3 12N4 13N2 14N1 14N2 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 19N5 20N1 20N2 20N3 20N4 20N5 24N1 24N2 25N1 25N3 26N3 28N1 28N2 28N3 28N5 29N1 29N4 29N5 30N1 30N3 30N4 30N5 37N1 37N2 37N3 38N1 38N2 38N4 38N5 39N5 40N3 44N1 44N3 44N4 44N5 49N1 49N3 49N5 53N1 53N3 58N3 58N4 58N5 59N1 59N2 59N3 59N4 59N5 61N4 65N1 65N2 65N4 65N5 65N6 65N7 68N1 68N5 73N1 73N2 73N3 73N4 73N5 73N7 73N8 79N3 80N2 80N5
1.374	-	1.377	(111)	3N1 3N2 8N5 12N5 24N3 24N4 24N5 34N1 34N2 34N3 37N4 37N5 38N3 40N1 40N2 40N4 40N5 43N1 43N3 43N4 43N5 44N2 49N2 50N1 50N2 53N2 54N5 55N1 57N2 57N3 57N4 57N5 58N1 58N2 60N1 60N2 60N4 60N5 61N1 61N2 61N3 61N5 63N4 64N1 64N2 64N3 64N4 64N5 65N3 66N1 66N4 66N7 66N8 67N3 67N5 68N2 68N3 68N4 68N6 68N7 68N8 69N2 69N3 69N4 69N5 69N6 69N7 69N8 71N4 71N5 71N6 71N7 71N8 73N6 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N6 79N1 79N2 79N4 79N5 79N7 79N8 80N1 80N3 80N4 80N6 80N7 80N8 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8
1.377	-	1.380	(41)	34N4 43N2 47N1 47N2 47N3 53N4 55N2 55N3 55N4 57N1 60N3 63N2 63N3 63N5 66N2 66N3 66N5 66N6 67N1 67N2 67N4 67N6 67N7 67N8 69N1 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N3 78N1 78N2 78N3 78N4 78N5 78N7 78N8 79N6
1.380	-	1.383	(25)	22N5 34N5 47N4 47N5 49N4 50N3 50N4 50N5 53N5 54N4 55N5 63N1 70N1 70N2 70N3 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 96N1 96N4
1.383	-	1.386	(16)	22N1 22N2 22N3 22N4 31N3 31N4 31N5 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 96N2
1.386	-	1.389	(8)	27N1 27N2 27N3 27N4 27N5 31N1 31N2 96N3

EOCTEST4

BASELINE TESTS NO 4 INTERNAL SHORT TESTS (OPEN CIRCUIT VOLTAGE)
BY PACK,CELL POSITION

VARIABLE NO. 52

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.257000	1.80500	1.54800	369	1.21180	.780564E-01

.2000	-	.3000	(2)	13N4 26N3
.3000	-	.4000	(0)	
.4000	-	.5000	(0)	
.5000	-	.6000	(0)	
.6000	-	.7000	(0)	
.7000	-	.8000	(0)	
.8000	-	.9000	(0)	
.9000	-	1.000	(0)	
1.000	-	1.100	(0)	
1.100	-	1.200	(39)	3N1 3N2 3N3 3N4 3N5 4N3 5N1 5N3 7N3 7N5 9N1 9N2 9N3 9N4 9N5 10N1 13N1 13N2 13N3 13N5 20N1 20N5 26N1 26N2 26N4 26N5 30N1 30N2 30N3 30N4 30N5 39N5 40N1 40N2 40N3 46N3 46N4 46N5 66N6
1.200	-	1.300	(327)	2N1 2N2 2N3 2N4 2N5 4N1 4N2 4N4 4N5 5N2 5N4 5N5 6N1 6N2 6N3 6N4 6N5 7N1 7N2 7N4 8N1 8N2 8N3 8N4 8N5 10N2 10N3 10N4 10N5 11N1 11N2 11N3 11N4 11N5 12N1 12N2 12N3 12N4 12N5 14N1 14N2 14N3 14N4 14N5 15N1 15N2 15N3 15N4 15N5 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 18N1 18N2 18N3 18N4 18N5 19N1 19N2 19N3 19N4 19N5 20N2 20N3 20N4 21N1 21N2 21N3 21N4 21N5 23N1 23N2 23N3 23N4 23N5 25N1 25N2 25N3 25N4 25N5 27N1 27N2 27N3 27N4 27N5 28N1 28N2 28N3 28N4 28N5 29N1 29N2 29N3 29N4 29N5 31N1 31N2 31N3 31N4 31N5 33N1 33N2 33N3 33N4 33N5 35N1 35N2 35N3 35N4 35N5 36N1 36N2 36N3 36N4 36N5 37N1 37N2 37N3 37N4 37N5 39N1 39N2 39N3 39N4 40N4 41N1 41N2 41N3 41N4 41N5 43N1 43N2 43N3 43N4 43N5 45N1 45N2 45N3 45N4 45N5 46N1 46N2 47N1 47N2 47N3 47N4 47N5 50N1 50N2 50N3 50N4 50N5 51N1 51N2 51N3 51N4 51N5 52N1 52N2 52N3 52N4 52N5 54N1 54N2 54N3 54N4 54N5 55N1 55N2 55N3 55N4 55N5 56N1 56N2 56N3 56N4 56N5 57N1 57N2 57N3 57N4 57N5 58N1 58N2 58N3 58N4 58N5 60N1 60N2 60N3 60N4 60N5 61N1 61N2 61N3 61N4 61N5 62N1 62N2 62N3 62N4 62N5 63N1 63N2 63N3 63N4 63N5 64N1 64N2 64N3 64N4 64N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 66N1 66N2 66N3 66N4 66N5 66N7 66N8 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N1 68N2 68N3 68N4 68N5 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 73N1 73N2 73N3 73N4 73N5 73N6 73N7 73N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8 82N1 82N2 82N3 82N4 82N5
1.300	-	1.400	(0)	
1.400	-	1.500	(0)	
1.500	-	1.600	(0)	
1.600	-	1.700	(0)	
1.700	-	1.800	(0)	
1.800	-	1.900	(1)	40N5

EOCTESTS

VARIABLE NO. 53 BASELINE TESTS NO 5 EOC VOLTAGE (CHG C/10 16HR MATRIX TEMPERATURE) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.704000	1.45300	.749000	433	1.39767	.456810E-01

.7000	-	.7700	(1)	48N5
.7700	-	.8400	(0)	
.8400	-	.9100	(0)	
.9100	-	.9800	(0)	
.9800	-	1.050	(1)	46N1
1.050	-	1.120	(0)	
1.120	-	1.190	(0)	
1.190	-	1.260	(0)	
1.260	-	1.330	(0)	
1.330	-	1.400	(263)	2N1 2N2 2N3 2N4 2N5 3N1 3N2 3N3 3N4 3N5 6N1 6N2 6N3 6N4 6N5 7N1 7N2 7N3 7N4 7N5 9N1 9N2 9N3 9N4 9N5 10N1 10N2 10N3 10N4 10N5 12N1 12N2 12N3 12N4 12N5 13N1 13N2 13N3 13N4 13N5 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 20N1 20N2 20N3 20N4 20N5 21N1 21N2 21N3 21N4 21N5 24N1 24N2 24N3 24N4 24N5 25N1 25N2 25N3 25N4 25N5 26N1 26N2 26N3 26N4 26N5 29N1 29N2 29N3 29N4 29N5 30N1 30N2 30N3 30N4 30N5 31N1 31N2 31N3 31N4 31N5 34N1 34N2 34N3 34N4 34N5 38N1 38N2 38N3 38N4 38N5 44N1 44N2 44N3 44N4 44N5 48N1 48N2 48N3 48N4 49N1 49N2 49N3 49N4 49N5 53N1 53N2 53N3 53N4 53N5 55N1 55N2 55N3 55N4 55N5 57N1 57N2 57N3 57N4 57N5 59N1 59N2 59N3 59N4 59N5 61N1 61N2 61N3 61N4 61N5 63N1 63N2 63N3 63N4 63N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N1 68N2 68N3 68N4 68N5 68N6 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 76N1 76N2 76N3 76N4 76N5 76N6 76N7 76N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N1 81N2 81N4 81N5 81N6 81N7 81N8
1.400	-	1.470	(168)	1N1 1N2 1N3 1N4 1N5 4N1 4N2 4N3 4N4 4N5 5N1 5N2 5N3 5N4 5N5 8N1 8N2 8N3 8N4 8N5 11N1 11N2 11N3 11N4 11N5 14N1 14N2 14N3 14N4 14N5 15N1 15N2 15N3 15N4 15N5 18N1 18N2 18N3 18N4 18N5 19N1 19N2 19N3 19N4 19N5 22N1 22N2 22N3 22N4 22N5 23N1 23N2 23N3 23N4 23N5 28N1 28N2 28N3 28N4 28N5 32N1 32N2 32N3 32N4 32N5 33N1 33N2 33N3 33N4 33N5 36N1 36N2 36N3 36N4 36N5 37N1 37N2 37N3 37N4 37N5 40N1 40N2 40N3 40N4 40N5 41N1 41N2 41N3 41N4 41N5 42N1 42N2 42N3 42N4 42N5 43N1 43N2 43N3 43N4 43N5 45N1 45N2 45N3 45N4 45N5 47N1 47N2 47N3 47N4 47N5 50N1 50N2 50N3 50N4 50N5 52N1 52N2 52N3 52N4 52N5 54N1 54N2 54N3 54N4 54N5 56N1 56N2 56N3 56N4 56N5 58N1 58N2 58N3 58N4 58N5 60N1 60N2 60N3 60N4 60N5 62N1 62N2 62N3 62N4 62N5 64N1 64N2 64N3 64N4 64N5 66N1 66N2 66N3 66N4 66N5 66N6 66N7 66N8 81N3 82N1 82N2 82N3 82N4 82N5 96N1 96N2 96N3 96N4

EOCTEST6

VARIABLE NO. 54 BASELINE TESTS NO 6 EOC VOLTAGE (MATRIX TEMPERATURE AND RATE) BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.37200	1.56800	.216000	414	1.45970	.450604E-01

1.360	-	1.380	(2)	11N4 15N2
1.380	-	1.400	(49)	11N2 11N3 11N4 11N5 15N1 15N3 15N4 15N5 18N1 18N2 18N3 18N4 18N5 22N1 22N2 22N3 22N4 22N5 32N1 32N2 32N3 32N4 32N5 36N1 36N2 36N3 40N1 40N2 40N3 40N4 40N5 46N1 46N2 46N3 46N4 46N5 51N1 51N2 51N3 51N4 51N5 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8
1.400	-	1.420	(20)	5N1 5N2 5N3 5N4 5N5 25N1 25N2 25N3 25N4 25N5 36N4 36N5 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8
1.420	-	1.440	(83)	8N1 8N2 8N3 8N4 8N5 23N1 23N2 23N3 23N4 23N5 27N1 27N2 27N3 27N4 29N1 29N2 29N3 29N4 29N5 31N1 31N2 31N3 31N4 31N5 38N1 38N2 38N3 38N4 38N5 53N3 54N1 54N2 54N3 54N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 74N5 75N1 75N2 75N4 75N5 75N6 75N7 75N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8 82N1 82N2 82N3 82N4 82N5 96N1 96N2 96N3 96N4
1.440	-	1.460	(47)	4N1 4N2 4N3 4N4 4N5 19N1 19N2 19N3 19N4 21N1 21N2 21N3 21N4 21N5 24N2 24N4 27N5 34N1 34N2 34N3 34N4 34N5 44N3 49N1 49N2 49N3 49N4 49N5 53N1 53N2 53N4 53N5 54N4 59N1 59N2 59N3 59N4 59N5 74N1 74N2 74N3 74N4 74N6 74N7 74N8 75N3 76N2
1.460	-	1.480	(81)	9N3 9N4 9N5 12N1 12N2 13N1 13N2 13N3 13N4 13N5 16N1 16N2 16N3 16N4 16N5 17N1 17N3 17N4 17N5 19N5 24N1 24N3 24N5 26N1 26N2 26N3 26N4 26N5 37N5 39N4 44N1 44N2 44N4 44N5 48N3 48N4 48N5 66N1 66N4 66N5 66N6 66N7 66N8 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 76N1 76N3 76N4 76N5 76N6 76N7 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8
1.480	-	1.500	(70)	2N1 2N5 7N1 7N2 7N4 7N5 9N1 9N2 12N3 12N4 12N5 17N2 28N1 28N2 28N3 28N4 28N5 30N1 30N2 30N3 30N4 30N5 33N1 33N2 33N4 33N5 37N1 37N2 37N3 37N4 39N1 39N2 39N3 39N5 43N1 43N2 43N3 43N4 43N5 47N1 47N2 47N3 47N4 47N5 48N1 50N1 50N2 50N3 50N4 50N5 58N1 58N2 58N3 58N4 60N1 60N2 60N3 60N4 60N5 63N2 63N3 63N4 64N1 64N2 64N3 64N4 64N5 66N2 66N3 76N8
1.500	-	1.520	(21)	2N2 2N3 2N4 6N1 6N2 6N3 6N4 6N5 7N3 33N3 45N2 45N3 45N4 48N2 52N1 52N2 52N3 52N4 52N5 56N5 63N5
1.520	-	1.540	(17)	3N1 3N2 3N3 3N4 3N5 20N2 20N5 45N1 45N5 63N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8
1.540	-	1.560	(12)	20N1 20N3 20N4 41N3 41N4 41N5 56N3 56N4 62N3 62N4 62N5 70N1
1.560	-	1.580	(9)	35N1 35N3 35N4 35N5 41N1 41N2 56N1 56N2 62N2
1.580	-	1.600	(3)	35N2 56N5 62N1

EOCPRES1

VARIABLE NO. 55 BASELINE TESTS NO 1 EOC PRESSURE (CHG C/20 40 HR 20 DEGREES C) BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
3.00000	72.0000	69.0000	169	20.5325	10.6021

0.	-	6.000	(3)	5N1 53N2 72N3
6.000	-	12.00	(12)	4N1 4N2 9N2 10N2 26N2 44N1 48N2 66N2 68N3 70N1 79N2 82N2
12.00	-	18.00	(59)	6N2 8N1 8N2 10N1 13N2 14N1 14N2 17N2 22N1 23N1 23N2 24N1 25N1 25N2 27N2 29N1 31N2 32N1 36N2 39N1 39N2 41N1 41N2 43N1 43N2 45N1 50N1 52N2 53N1 55N1 55N2 56N2 58N1 58N2 60N1 60N2 62N1 63N2 64N2 65N2 67N1 67N2 67N3 69N1 71N2 71N3 72N2 73N3 74N1 74N2 75N1 75N3 77N2 77N3 78N2 80N2 81N2 81N3 82N1
18.00	-	24.00	(56)	1N2 3N1 3N2 5N2 9N1 11N2 12N2 13N1 15N1 15N2 16N2 17N1 19N1 19N2 22N2 24N2 26N1 27N1 30N1 31N1 32N2 33N1 34N1 34N2 35N1 36N1 37N1 37N2 44N2 45N2 47N1 47N2 48N1 50N2 52N1 54N1 57N2 59N1 59N2 61N2 63N1 64N1 65N1 65N3 66N1 66N3 70N2 70N3 72N1 74N3 75N2 77N1 78N1 78N3 79N1 79N3
24.00	-	30.00	(18)	6N1 7N2 12N1 20N2 28N1 28N2 33N2 49N1 51N1 54N2 57N1 61N1 71N1 76N1 76N2 76N3 80N1 80N3
30.00	-	36.00	(11)	2N2 7N1 16N1 18N1 20N1 35N2 38N1 38N2 46N1 49N2 51N2
36.00	-	42.00	(2)	21N1 69N2
42.00	-	48.00	(2)	2N1 40N1
48.00	-	54.00	(2)	11N1 18N2
54.00	-	60.00	(0)	
60.00	-	66.00	(1)	40N2
66.00	-	72.00	(2)	1N1 21N2
72.00	-	78.00	(1)	46N2

EOCPRES2 BASELINE TESTS NO 2 EOC PRESSURE (CHG C/10 16 HR 20 DEGREES C)

VARIABLE NO. 56 BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
10.0000	86.0000	76.0000	168	26.2381	11.6877

7.000	-	14.00	(9)	22N1 32N1 32N2 34N1 36N2 53N2 72N3 79N2 82N2
14.00	-	21.00	(50)	1N2 6N2 8N1 8N2 9N2 10N1 10N2 15N1 17N2 22N2 26N2 34N2 35N1 36N1 39N1 39N2 41N1 41N2 43N1 43N2 44N1 44N2 45N1 45N2 50N1 52N2 53N1 55N1 55N2 56N1 56N2 58N1 58N2 60N1 60N2 62N1 64N2 65N1 65N2 65N3 66N1 70N1 71N2 71N3 75N1 75N3 77N2 77N3 81N2 81N3
21.00	-	28.00	(55)	3N1 3N2 4N1 12N2 14N2 15N2 16N2 17N1 18N1 19N1 19N2 23N1 24N1 24N2 25N1 25N2 27N2 29N1 29N2 31N1 31N2 35N2 37N1 37N2 48N1 48N2 50N2 52N1 57N2 59N1 61N2 63N2 64N1 66N3 67N1 67N2 67N3 68N3 69N1 71N1 72N1 72N2 73N3 74N1 74N2 74N3 75N2 77N1 78N1 78N2 78N3 79N1 79N3 80N2 82N1
28.00	-	35.00	(24)	1N1 4N2 6N1 12N1 13N1 13N2 14N1 18N2 23N2 26N1 27N1 28N2 33N1 49N1 54N1 57N1 59N2 61N1 63N1 66N2 70N2 70N3 80N1 80N3
35.00	-	42.00	(13)	2N2 9N1 16N1 21N1 28N1 30N1 33N2 46N1 46N2 54N2 76N1 76N2 76N3
42.00	-	49.00	(7)	2N1 20N2 40N1 40N2 49N2 51N1 69N2
49.00	-	56.00	(4)	5N1 5N2 7N2 38N1
56.00	-	63.00	(3)	7N1 38N2 51N2
63.00	-	70.00	(2)	20N1 21N2
70.00	-	77.00	(0)	
77.00	-	84.00	(0)	
84.00	-	91.00	(1)	11N2

EOCPRES3

VARIABLE NO. 57 BASELINE TESTS NO 3 EOC PRESSURE (CHG C/40 20 HR 20 DEGREES C)
BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	57.0000	56.0000	155	13.7419	7.89447

0.	-	5.000	(6)	46N1 55N1 63N2 70N1 73N1 81N3
5.000	-	10.00	(40)	1N2 4N2 9N2 10N2 12N1 12N2 15N1 15N2 18N1 18N2 20N1 20N2 21N2 26N1 30N1 31N1 31N2 38N1 38N2 40N2 46N2 51N2 53N1 59N1 59N2 63N1 65N2 66N1 66N3 68N2 68N3 73N2 73N3 74N1 74N2 76N1 79N2 80N2 81N2 82N2
10.00	-	15.00	(48)	2N1 4N1 6N2 7N1 7N2 8N1 9N1 10N1 13N2 14N2 17N2 23N1 24N1 24N2 25N2 27N2 28N1 28N2 33N1 34N1 40N1 43N2 45N1 48N1 50N1 54N2 55N2 56N2 57N1 57N2 61N1 65N1 65N3 66N2 67N1 67N2 67N3 68N1 72N1 72N2 74N3 75N3 76N2 76N3 78N2 79N3 80N1 80N3
15.00	-	20.00	(45)	2N2 3N1 3N2 8N2 13N1 14N1 14N2 16N1 17N1 19N1 19N2 23N2 25N1 27N1 29N1 29N2 33N2 34N2 35N1 35N2 41N1 41N2 43N1 45N2 50N2 52N1 52N2 54N1 58N1 58N2 60N1 60N2 61N2 62N1 64N1 64N2 69N1 70N2 70N3 75N1 75N2 78N1 78N3 79N1 82N1
20.00	-	25.00	(4)	1N1 36N2 39N1 39N2
25.00	-	30.00	(3)	6N1 22N1 36N1
30.00	-	35.00	(5)	5N2 22N2 47N1 47N2 69N2
35.00	-	40.00	(1)	5N1
40.00	-	45.00	(1)	44N1
45.00	-	50.00	(0)	
50.00	-	55.00	(1)	11N2
55.00	-	60.00	(1)	44N2

EOCPRES4

BASELINE TESTS NO 4 INTERNAL SHORT TESTS
BY PACK.CELL POSITION

VARIABLE NO. 56

MIN	MAX	RANGE	N	MEAN	STD. DEV.
2.00000	38.0000	36.0000	119	13.6891	6.17643

0.	-	3.000	(1)	73N1
3.000	-	6.000	(4)	18N1 55N1 63N2 71N3
6.000	-	9.000	(18)	9N2 10N2 12N1 12N2 15N1 15N2 18N2 20N2 21N2 31N2 51N2 63N1 65N2 66N1 70N3 71N2 73N2 82N2
9.000	-	12.00	(20)	7N2 13N2 16N2 20N1 26N1 27N2 28N2 31N1 40N1 40N2 45N1 57N1 65N3 68N2 68N3 70N2 73N3 74N1 74N2 81N3
12.00	-	15.00	(26)	2N1 6N2 7N1 8N1 9N1 10N1 17N2 23N1 25N2 28N3 30N1 33N1 41N2 43N2 50N1 54N2 55N2 56N2 57N2 65N1 67N2 67N3 74N3 78N1 78N2 81N2
15.00	-	18.00	(33)	2N2 4N2 13N1 14N2 16N1 17N1 23N2 25N1 27N1 29N1 29N2 33N2 41N1 43N1 45N2 50N2 54N1 58N1 58N2 60N1 60N2 61N1 61N2 62N1 64N1 64N2 66N2 66N3 68N1 71N1 75N3 78N3 82N1
18.00	-	21.00	(8)	3N1 3N2 14N1 19N1 19N2 37N1 37N2 75N1
21.00	-	24.00	(0)	
24.00	-	27.00	(2)	69N1 75N2
27.00	-	30.00	(3)	6N1 36N1 47N2
30.00	-	33.00	(2)	36N2 47N1
33.00	-	36.00	(1)	69N2
36.00	-	39.00	(1)	11N2

EOCPRESS

VARIABLE NO. 59 BASELINE TEST NO 5 EOC PRESSURE (CHG C/10 16HR MATRIX TEMPERATURE) BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	75.0000	74.0000	159	18.4780	8.24992

0.	-	7.000	(6)	21N1 26N2 48N2 53N2 67N1 72N3
7.000	-	14.00	(22)	9N2 10N2 12N2 16N2 20N2 31N1 31N2 44N1 55N1 63N2 65N2 65N3 66N1 68N2 68N3 70N1 71N2 71N3 77N2 77N3 7N2 82N2
14.00	-	21.00	(89)	7N2 8N1 8N2 9N1 10N1 12N1 13N2 14N1 14N2 14N1 17N1 17N2 18N1 18N2 19N1 19N2 21N2 22N1 23N1 23N2 24N1 24N2 25N1 25N2 28N2 28N3 29N1 29N2 30N1 32N1 33N1 34N1 36N2 38N1 38N2 40N1 40N2 41N1 41N2 42N2 43N1 43N2 45N1 45N2 48N1 49N1 49N2 52N1 52N2 53N1 54N1 54N2 55N2 56N1 56N2 57N2 58N1 58N2 59N1 59N2 60N1 60N2 61N1 61N2 62N1 63N1 64N1 64N2 65N1 66N3 67N2 67N3 68N1 69N1 72N2 74N1 74N2 74N3 75N1 75N3 76N1 76N2 76N3 77N1 78N1 78N2 79N3 80N2 82N1
21.00	-	28.00	(30)	2N1 2N2 3N1 3N2 7N1 13N1 15N1 15N2 20N1 22N2 26N1 33N2 34N2 36N1 37N1 37N2 42N1 44N2 57N1 64N2 70N2 70N3 71N1 72N1 75N2 78N3 79N1 80N1 80N3 81N3
28.00	-	35.00	(6)	1N2 5N2 6N1 32N2 47N2 81N2
35.00	-	42.00	(3)	5N1 47N1 69N2
42.00	-	49.00	(1)	11N1
49.00	-	56.00	(1)	1N1
56.00	-	63.00	(0)	
63.00	-	70.00	(0)	
70.00	-	77.00	(1)	11N2

EOCPRES6

BASELINE TESTS NO 6 EOC PRESSURE (MATRIX TEMPERATURE AND RATE)

VARIABLE NO. 60 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
3.00000	97.0000	94.0000	152	29.6250	22.5435

0.	-	9.000	(11)	9N2 15N1 15N2 18N1 21N1 35N1 46N1 53N2 65N2 71N3 82N2
9.000	-	18.00	(52)	8N1 8N2 9N1 11N1 13N1 13N2 18N2 22N1 23N1 24N1 25N2 26N1 27N2 29N2 30N1 31N1 31N2 32N1 34N1 36N1 36N2 38N1 38N2 40N1 41N1 44N1 46N2 48N2 49N1 49N2 50N1 50N2 51N2 53N1 56N2 59N1 59N2 62N1 65N1 65N3 67N2 67N3 69N1 71N2 74N1 74N2 74N3 75N3 81N1 81N2 81N3 82N1
18.00	-	27.00	(34)	5N1 5N2 7N1 7N2 12N1 16N1 16N2 17N1 17N2 21N2 22N2 23N2 24N2 25N1 27N1 29N1 32N2 34N2 37N2 40N2 44N2 48N1 54N1 54N2 56N1 60N2 64N1 64N2 71N1 75N1 75N2 78N1 78N2 78N3
27.00	-	36.00	(10)	33N1 33N2 37N1 43N2 47N1 47N2 60N1 77N3 79N1 79N2
36.00	-	45.00	(12)	3N2 11N2 19N1 19N2 28N3 43N1 66N1 69N2 72N2 72N3 77N1 77N2
45.00	-	54.00	(7)	3N1 66N3 76N2 79N3 80N1 80N2 80N3
54.00	-	63.00	(8)	20N1 20N2 28N2 52N1 52N2 66N2 72N1 76N3
63.00	-	72.00	(6)	6N2 45N1 63N1 63N2 70N1 70N2
72.00	-	81.00	(5)	5N1 39N2 45N2 58N1 70N3
81.00	-	90.00	(4)	12N2 39N1 58N2 76N1
90.00	-	99.00	(3)	2N1 2N2 35N2

EODCAP 1

VARIABLE NO. 61 BASELINE TESTS NO 1 EOD CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C) BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.11900	8.63000	7.51100	415	7.18252	.962483

.7000	-	1.400	(5)	47N1 47N2 47N3 47N4 47N5
1.400	-	2.100	(0)	
2.100	-	2.800	(0)	
2.800	-	3.500	(0)	
3.500	-	4.200	(0)	
4.200	-	4.900	(13)	43N1 43N3 43N5 60N1 60N2 60N3 60N4 60N5 64N1 64N2 64N3 64N4 64N5
4.900	-	5.600	(3)	15N5 43N2 43N4
5.600	-	6.300	(11)	15N4 28N1 28N2 28N3 28N4 28N5 56N1 56N2 56N3 56N4 56N5
6.300	-	7.000	(62)	5N5 11N1 11N2 11N4 11N5 15N1 15N2 15N3 24N2 38N1 38N2 38N3 38N4 38N5 39N1 39N2 39N3 39N4 39N5 46N3 51N3 51N4 51N5 52N1 52N3 52N4 52N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 66N2 68N4 68N6 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 73N1 76N1 76N3 76N4 76N5 76N6 76N7 76N8 77N2 79N1 79N2 79N4 79N5 79N7 79N8 96N1
7.000	-	7.700	(208)	1N1 1N2 1N3 1N4 1N5 5N1 5N2 5N3 5N4 7N3 7N5 11N3 13N3 13N4 13N5 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 20N2 20N5 21N1 21N2 21N3 21N4 21N5 24N1 24N3 24N4 24N5 30N1 30N2 30N3 30N4 30N5 31N3 31N4 31N5 33N3 33N4 33N5 40N4 41N4 41N5 44N1 44N2 44N3 44N4 44N5 46N1 46N2 48N1 48N2 48N3 48N4 48N5 49N1 49N2 49N3 49N4 49N5 50N5 51N1 51N2 52N2 53N1 53N2 53N3 53N4 53N5 55N1 55N3 57N1 57N5 59N1 59N2 59N3 59N4 59N5 61N1 61N2 61N3 61N4 61N5 62N2 62N3 62N4 63N1 63N2 63N3 63N4 63N5 66N1 66N3 66N4 66N5 66N6 66N7 66N8 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N1 68N2 68N3 68N5 68N7 68N8 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 73N2 73N3 73N4 73N5 73N6 73N7 73N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 76N2 77N1 77N3 77N4 77N5 77N6 77N7 77N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N3 79N6 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8 82N1 82N2 82N3 82N4 82N5 96N2 96N3 96N4
7.700	-	8.400	(111)	2N1 2N2 2N3 2N4 2N5 3N1 3N2 3N3 3N4 3N5 6N1 6N2 6N3 6N4 6N5 7N1 7N2 7N4 9N1 9N2 9N3 9N4 9N5 13N1 13N2 18N1 18N2 18N3 18N4 18N5 20N1 20N3 20N4 22N1 22N2 22N3 22N4 22N5 26N3 26N4 26N5 27N1 27N2 27N3 27N4 27N5 31N1 31N2 32N1 32N2 32N3 32N4 32N5 33N1 33N2 34N1 34N2 34N3 34N4 34N5 35N1 35N2 35N3 35N4 35N5 36N1 36N2 36N3 36N4 36N5 37N1 37N2 37N3 37N4 37N5 40N1 40N2 40N3 40N5 41N1 41N2 41N3 45N1 45N2 45N3 45N4 45N5 46N4 46N5 50N1 50N2 50N3 50N4 54N1 54N2 54N3 54N4 54N5 55N2 55N4 55N5 57N2 57N3 57N4 58N1 58N2 58N3 58N4 58N5 62N1 62N5
8.400	-	9.100	(2)	26N1 26N2

EDUCAP 2

VARIABLE NO. 62 BASELINE TESTS NO 2 EOD CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C)
BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
3.92000	8.19000	4.27000	435	7.23931	.627552

3.600	-	4.000	(3)	34N3 34N4 34N5
4.000	-	4.400	(2)	34N1 34N2
4.400	-	4.800	(5)	11N1 11N2 11N3 11N4 11N5
4.800	-	5.200	(0)	
5.200	-	5.600	(0)	
5.600	-	6.000	(0)	
6.000	-	6.400	(13)	40N1 40N2 40N4 40N5 76N5 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8
6.400	-	6.800	(33)	7N3 15N4 15N5 26N3 26N4 28N2 29N3 33N4 33N5 40N3 51N3 51N4 51N5 57N1 72N2 72N3 72N4 72N5 72N6 72N8 73N1 75N6 76N4 76N7 76N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8
6.800	-	7.200	(142)	4N5 7N5 10N1 10N3 10N4 10N5 12N4 12N5 13N2 13N3 13N4 13N5 15N1 15N2 15N3 18N1 18N2 18N4 18N5 20N5 26N2 26N5 28N1 28N3 28N4 29N1 29N2 29N4 29N5 33N3 38N2 38N3 38N4 38N5 43N1 46N3 48N3 48N5 51N1 57N2 57N3 57N4 57N5 62N2 62N3 62N4 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 66N1 66N2 66N3 66N5 66N6 66N7 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N1 68N2 68N3 68N4 68N5 68N6 68N7 68N8 69N4 69N6 70N1 70N2 70N3 70N5 70N6 70N7 70N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 72N1 72N7 73N2 73N3 73N4 73N5 73N6 73N7 73N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8 75N1 75N2 75N3 75N4 75N5 75N7 75N8 76N1 76N2 76N3 76N6 78N1 78N2 78N3 78N4 78N5 78N7 78N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8 81N1 81N2 81N7 82N1 82N2 82N4
7.200	-	7.600	(116)	1N1 1N2 1N3 2N1 4N2 4N3 4N4 5N1 5N2 5N3 5N4 5N5 8N1 8N2 8N3 8N4 8N5 10N2 12N3 13N1 14N1 14N3 14N4 14N5 16N1 16N2 16N3 16N4 17N1 17N2 17N3 17N4 17N5 18N3 20N2 20N3 21N1 21N2 21N3 21N4 21N5 23N1 23N2 23N4 23N5 26N1 28N5 30N1 30N2 30N3 30N5 31N3 31N4 31N5 33N1 33N2 35N1 35N2 38N1 41N1 41N2 41N3 41N4 41N5 43N2 43N3 44N4 46N1 46N2 48N1 48N4 49N1 49N2 49N3 50N5 51N2 53N3 54N3 54N5 55N1 55N3 56N1 56N4 56N5 59N1 59N2 59N4 59N5 61N1 61N2 61N3 61N4 61N5 62N1 62N5 66N4 66N8 69N1 69N2 69N3 69N5 69N7 69N8 70N4 78N6 81N3 81N4 81N5 81N6 81N8 82N3 82N5 96N1 96N2 96N3 96N4
7.600	-	8.000	(108)	1N4 1N5 2N2 2N3 2N4 2N5 3N1 3N3 3N4 3N5 4N1 6N1 6N2 6N3 6N4 6N5 7N1 7N2 7N4 9N1 9N2 9N3 9N4 9N5 12N1 12N2 14N2 14N5 19N1 19N2 19N3 19N4 19N5 20N1 20N4 23N3 24N1 24N2 24N3 24N4 24N5 25N1 25N3 25N4 25N5 27N2 27N3 27N5 30N4 31N1 31N2 35N3 35N4 35N5 37N1 37N2 37N3 37N4 37N5 43N4 43N5 44N1 44N3 44N5 46N4 46N5 48N2 49N5 50N1 50N2 50N3 50N4 52N1 52N2 52N3 52N4 53N1 53N2 53N4 53N5 54N1 54N2 54N4 55N2 55N4 55N5 56N2 56N3 58N2 58N3 58N4 58N5 59N3 60N1 60N2 60N3 60N4 60N5 63N1 63N2 63N3 63N4 63N5 64N1 64N2 64N3 64N4 64N5
8.000	-	8.400	(13)	3N2 25N2 27N1 27N4 44N2 45N1 45N2 45N3 45N4 45N5 49N4 52N5 58N1

EOUCAP 3

VARIABLE NO. 63 BASELINE TESTS NO 3 EOU CAPACITY (DISCH C/2 TO .75 V/C AT 20 DEG C)
BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
.179000	2.59000	2.41100	419	1.53975	.479561

0.	-	.2000	(3)	30N1 30N2 30N5
.2000	-	.4000	(1)	45N3
.4000	-	.6000	(14)	30N3 30N4 36N1 36N2 36N3 45N1 45N2 45N4 58N4 64N1 64N2 64N3 64N4 64N5
.6000	-	.8000	(19)	8N2 14N3 14N5 19N1 19N2 19N4 19N5 25N1 25N2 36N4 36N5 41N3 45N5 52N1 52N2 58N1 58N2 58N3 58N5
.8000	-	1.000	(27)	8N1 8N3 8N4 14N1 14N2 14N4 19N3 25N3 25N4 25N5 37N1 37N2 41N1 41N2 41N4 41N5 47N2 47N3 47N4 47N5 48N2 50N2 52N3 52N4 52N5 56N1 56N4
1.000	-	1.200	(35)	3N1 3N3 3N4 3N5 6N3 8N5 9N2 16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 18N3 24N1 24N2 24N3 24N4 24N5 37N3 37N4 37N5 47N1 56N2 56N3 56N5 60N1 60N2 60N3 60N4 60N5
1.200	-	1.400	(34)	3N2 4N1 4N2 4N3 4N4 4N5 6N1 6N2 6N4 6N5 9N5 10N2 20N1 20N4 23N2 23N4 23N5 29N2 29N3 29N4 43N1 43N2 43N3 43N4 43N5 44N1 44N2 44N3 44N4 44N5 48N1 50N1 54N4 62N1
1.400	-	1.600	(73)	2N1 2N2 2N3 2N4 2N5 7N1 9N1 9N3 9N4 10N1 10N3 10N4 10N5 12N1 12N2 12N4 13N1 13N2 18N2 20N2 20N3 20N5 21N2 21N3 21N4 21N5 23N1 23N3 29N5 33N1 34N1 34N2 34N3 34N4 34N5 38N1 48N4 49N1 49N2 49N3 49N4 49N5 50N3 50N4 50N5 53N1 53N2 53N3 53N4 53N5 54N1 54N2 54N3 54N5 55N1 55N2 55N3 59N1 59N3 59N5 61N1 61N2 61N3 61N4 61N5 73N1 73N2 73N3 73N4 73N5 73N6 73N7 96N1
1.600	-	1.800	(92)	7N2 7N5 12N3 12N5 18N1 18N4 18N5 26N1 26N2 26N5 29N1 33N2 33N3 33N4 33N5 38N2 38N3 38N4 38N5 40N1 40N2 40N3 40N4 40N5 46N3 46N4 46N5 48N3 48N5 55N4 55N5 59N2 59N4 62N2 62N3 62N4 62N5 63N1 63N2 63N3 63N4 63N5 66N2 66N3 68N1 68N2 68N3 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 73N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 77N1 77N2 77N3 77N4 77N5 77N6 77N7 77N8 80N1 80N2 80N3 80N4 80N5 80N7 80N8 82N1 82N2 82N3 82N5 96N2 96N3
1.800	-	2.000	(65)	7N4 13N4 21N1 26N3 26N4 46N1 46N2 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 66N1 66N4 66N5 66N6 66N7 66N8 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 68N4 68N5 68N6 68N7 68N8 69N1 69N2 76N1 76N4 76N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N6 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8 82N4
2.000	-	2.200	(32)	7N3 13N3 13N5 27N1 27N2 27N4 27N5 69N3 69N4 69N5 69N6 69N7 69N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 72N1 72N2 72N3 72N5 72N7 76N2 76N3 76N5 76N6 76N7 96N4
2.200	-	2.400	(10)	27N3 28N1 28N2 28N3 28N4 28N5 57N5 72N4 72N6 72N8
2.400	-	2.600	(14)	31N1 31N2 31N3 31N4 31N5 51N1 51N2 51N3 51N4 51N5 57N1 57N2 57N3 57N4

EDUCAP 5 VARIABLE NO. 65 BASELINE TESTS NO 5 EDU CAPACITY (DISCH C/2 TO .75 V/C MATRIX TEMP) BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
2.19000	8.08900	5.89900	417	5.80797	1.44816

2.000	-	2.500	(1)	48N5
2.500	-	3.000	(3)	48N1 48N3 48N4
3.000	-	3.500	(12)	13N1 49N1 49N2 49N3 49N4 49N5 53N3 59N1 59N2 59N3 59N4 59N5
3.500	-	4.000	(36)	9N1 9N2 9N3 9N4 9N5 13N2 13N3 13N4 13N5 26N1 26N2 26N3 26N4 26N5 38N1 46N1 46N2 46N3 46N4 46N5 51N1 51N2 51N3 51N4 51N5 53N4 53N5 55N4 55N5 57N1 57N2 57N3 57N4 57N5 74N4 74N7
4.000	-	4.500	(54)	2N2 2N3 2N4 7N1 7N2 7N3 7N4 7N5 20N1 20N2 20N3 20N4 20N5 24N5 31N1 31N2 31N3 31N4 31N5 34N4 34N5 38N2 38N3 38N4 38N5 48N2 53N1 53N2 55N1 55N2 55N3 61N1 61N2 61N3 61N4 61N5 63N2 63N3 63N4 63N5 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8 74N1 74N2 74N3 74N5 74N6 74N8
4.500	-	5.000	(28)	2N1 2N5 3N1 3N2 3N3 3N4 3N5 24N1 24N2 24N3 24N4 30N1 30N2 30N3 30N4 30N5 34N1 34N2 34N3 63N1 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8
5.000	-	5.500	(39)	6N1 6N2 6N3 6N4 6N5 27N1 27N2 27N3 27N4 27N5 44N2 44N3 68N1 68N2 68N3 68N4 68N5 68N6 68N7 68N8 69N6 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 77N2 77N4 77N5 77N7 78N3 78N4 78N5 78N6 78N7 78N8
5.500	-	6.000	(43)	12N1 12N2 12N3 12N4 12N5 21N1 21N2 21N3 21N4 21N5 29N1 29N2 29N3 29N4 29N5 44N1 44N4 44N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 69N1 69N2 69N3 69N4 69N5 69N7 69N8 76N4 76N5 76N7 76N8 77N1 77N3 77N6 77N8 78N1 78N2
6.000	-	6.500	(53)	62N4 66N1 66N2 66N3 66N4 66N5 66N6 66N7 66N8 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 76N1 76N2 76N3 76N6 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8 96N1
6.500	-	7.000	(29)	16N1 16N2 16N3 16N4 16N5 17N1 17N2 17N3 17N4 17N5 23N1 23N2 23N3 23N4 23N5 25N1 25N2 25N3 25N4 25N5 62N1 62N2 62N3 62N5 80N8 82N2 96N2 96N3 96N4
7.000	-	7.500	(48)	1N1 1N2 1N3 1N4 4N1 4N2 4N3 4N4 4N5 5N1 5N2 5N3 5N4 5N5 11N2 11N4 11N5 15N4 15N5 28N1 28N2 28N3 28N4 35N1 41N1 41N2 41N3 41N4 41N5 47N1 47N2 47N3 47N4 47N5 50N1 50N2 50N3 50N4 50N5 56N1 56N2 56N3 56N4 56N5 82N1 82N3 82N4 82N5
7.500	-	8.000	(65)	1N5 8N1 8N2 8N3 8N4 8N5 11N1 11N3 15N1 15N2 15N3 18N1 18N2 18N3 18N4 18N5 19N1 19N2 19N3 19N4 19N5 22N2 22N3 22N4 22N5 28N5 32N1 32N2 32N4 32N5 35N2 35N3 35N4 35N5 36N1 36N2 36N3 39N1 39N2 39N3 39N4 39N5 40N1 40N3 40N4 40N5 42N1 42N2 42N3 42N4 45N1 45N2 45N3 45N4 45N5 52N1 52N2 52N3 52N4 52N5 58N1 58N2 58N3 58N4 58N5
8.000	-	8.500	(6)	22N1 32N3 36N4 36N5 40N2 42N5

EOUCAP 6

VARIABLE NO. 66 BASELINE TESTS NO 6 EOU CAPACITY (DISCH MATRIX RATE + TEMP TO .50 V/C) BY PACK+CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.02000	8.26400	7.24400	394	4.97179	1.99310

.7000 - 1.400	(13)	25N1 25N2 25N3 25N4 25N5 67N1 67N2 67N3 67N4 67N5 67N6 67N7 67N8		
1.400 - 2.100	(15)	22N1 22N3 22N4 22N5 26N1 26N2 26N3 26N4 26N5 32N4 53N1 53N2 53N3 53N4 53N5		
2.100 - 2.800	(43)	9N1 9N2 9N3 9N4 9N5 18N1 18N2 18N3 18N4 18N5 22N1 31N1 31N2 31N3 31N4 31N5 32N1 32N2 32N3 32N5 40N1 40N2 40N3 40N4 40N5 46N1 46N2 46N3 46N4 46N5 51N1 51N2 51N3 51N4 51N5 69N1 69N2 69N3 69N4 69N5 69N6 69N7 69N8		
2.800 - 3.500	(37)	5N1 5N2 5N3 5N4 5N5 11N1 11N2 11N3 11N4 11N5 13N1 13N2 13N3 13N4 13N5 27N1 27N3 30N1 30N2 30N3 30N4 30N5 36N1 36N2 36N3 36N4 36N5 38N1 38N2 38N3 38N4 38N5 49N1 49N2 49N3 49N4 49N5		
3.500 - 4.200	(49)	15N1 15N2 15N3 15N4 15N5 27N2 27N4 27N5 34N1 34N2 34N3 34N4 34N5 65N1 65N2 65N3 65N4 65N5 65N6 65N7 65N8 71N1 71N2 71N3 71N4 71N5 71N6 71N7 71N8 75N1 75N2 75N3 75N4 75N5 75N6 75N7 75N8 78N1 78N2 78N3 78N4 78N5 78N6 78N7 78N8 96N1 96N2 96N3 96N4		
4.200 - 4.900	(33)	33N1 33N2 33N3 33N4 33N5 42N1 42N2 42N3 42N4 42N5 44N1 44N2 44N3 44N4 44N5 59N1 59N2 59N3 59N4 59N5 63N1 63N2 63N3 63N4 63N5 81N1 81N2 81N3 81N4 81N5 81N6 81N7 81N8		
4.900 - 5.600	(18)	7N1 7N2 7N3 7N4 7N5 16N3 16N4 17N3 24N1 24N2 24N3 24N4 24N5 82N1 82N2 82N3 82N4 82N5		
5.600 - 6.300	(39)	16N1 16N2 16N5 17N1 17N2 17N4 17N5 21N1 21N2 21N3 21N4 21N5 43N1 43N2 43N3 43N4 43N5 50N3 54N1 54N2 54N3 54N4 54N5 70N1 70N2 70N3 70N4 70N5 70N6 70N7 70N8 74N1 74N2 74N3 74N4 74N5 74N6 74N7 74N8		
6.300 - 7.000	(65)	3N3 3N5 12N4 12N5 41N3 41N4 41N5 47N5 48N1 48N2 48N3 48N4 48N5 50N1 50N2 50N5 56N5 60N3 60N4 60N5 64N1 64N2 64N3 64N4 64N5 66N2 66N3 72N1 72N2 72N3 72N4 72N5 72N6 72N7 72N8 76N1 76N2 76N3 76N4 76N5 76N6 76N7 76N8 77N1 77N2 77N3 77N6 77N7 77N8 79N1 79N2 79N3 79N4 79N5 79N6 79N7 79N8 80N1 80N2 80N3 80N4 80N5 80N6 80N7 80N8		
7.000 - 7.700	(63)	3N1 3N2 3N4 6N2 6N3 12N1 12N3 20N1 20N2 20N3 20N4 20N5 28N1 28N2 28N3 28N4 28N5 35N5 37N1 37N2 37N3 37N4 37N5 39N1 39N2 39N3 41N1 41N2 45N1 45N2 45N3 45N4 45N5 47N1 47N2 47N3 47N4 50N4 52N3 56N1 56N2 56N3 56N4 58N1 58N2 58N3 58N4 58N5 60N1 60N2 62N1 62N2 62N3 62N4 62N5 66N1 66N4 66N5 66N6 66N7 66N8 77N4 77N5		
7.700 - 8.400	(19)	2N1 2N2 2N3 2N4 2N5 6N1 6N4 6N5 12N2 35N1 35N2 35N3 35N4 39N4 39N5 52N1 52N2 52N4 52N5		

EOUPRES1 VARIABLE NO. 67 BASELINE TESTS NO 1 EQU PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C) BY PACK-CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	30.0000	29.0000	131	12.3511	4.63087

0.	-	2.000	(3)	48N2 51N1 82N2
2.000	-	4.000	(3)	55N1 63N2 81N3
4.000	-	6.000	(3)	44N1 46N1 71N3
6.000	-	8.000	(7)	6N2 49N1 65N2 66N2 98N3 71N2 81N2
8.000	-	10.00	(22)	16N2 18N1 20N2 26N1 30N1 31N2 32N1 38N2 46N2 59N1 59N2 63N1 67N1 67N2 69N1 72N2 73N3 74N1 74N2 76N1 79N2 82N1
10.00	-	12.00	(15)	9N1 13N2 17N2 27N2 31N1 34N1 38N1 49N2 53N1 65N3 67N3 76N3 77N2 77N3 80N2
12.00	-	14.00	(20)	7N1 7N2 22N1 24N1 28N1 32N2 43N2 48N1 55N2 56N2 57N1 57N2 65N1 70N2 70N3 72N1 74N3 75N3 76N2 80N1
14.00	-	16.00	(29)	2N1 2N2 13N1 16N1 17N1 18N2 20N1 21N2 24N2 28N2 33N1 36N1 36N2 40N1 41N2 54N2 58N2 60N1 60N2 61N1 61N2 62N1 64N2 66N3 75N1 77N1 78N2 79N3 80N3
16.00	-	18.00	(16)	3N2 27N1 33N2 35N1 39N1 39N2 41N1 43N1 44N2 52N2 54N1 58N1 64N1 71N1 78N1 78N3
18.00	-	20.00	(8)	3N1 22N2 35N2 51N2 52N1 66N1 75N2 79N1
20.00	-	22.00	(2)	37N1 37N2
22.00	-	24.00	(2)	6N1 40N2
24.00	-	26.00	(0)	
26.00	-	28.00	(0)	
28.00	-	30.00	(0)	
30.00	-	32.00	(1)	69N2

EOOPRES2

VARIABLE NO. 68 BASELINE TESTS NO 2 EOD PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C)
BY PACK•CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	72.0000	71.0000	151	14.2715	7.34206

0.	-	7.000	(12)	21N1 44N1 46N1 48N2 51N1 55N1 66N1 70N1 71N3 81N2 81N3 82N2
7.000	-	14.00	(52)	1N2 4N2 6N2 9N1 10N1 10N2 12N1 12N2 13N2 15N1 16N2 17N2 18N1 18N2 20N2 24N1 26N1 27N2 28N1 30N1 31N1 31N2 34N1 43N2 45N1 46N2 49N1 50N1 53N1 57N1 57N2 59N1 59N2 65N1 65N2 65N3 66N3 68N3 69N1 71N2 72N2 73N3 74N1 74N2 76N1 76N2 76N3 77N2 77N3 79N2 80N1 82N1
14.00	-	21.00	(79)	2N1 2N2 3N1 3N2 4N1 7N1 7N2 8N1 8N2 13N1 14N1 14N2 15N2 16N1 17N1 21N2 23N1 23N2 24N2 25N1 25N2 27N1 28N2 29N1 29N2 33N1 33N2 34N2 35N1 35N2 37N1 37N2 38N1 38N2 40N1 40N2 41N1 41N2 43N1 44N2 45N2 48N1 49N2 50N2 51N2 52N1 52N2 54N1 54N2 55N2 56N2 58N1 58N2 60N1 60N2 61N1 61N2 62N1 64N1 64N2 66N2 67N1 67N2 67N3 70N2 70N3 71N1 72N1 74N3 75N1 75N2 75N3 77N1 78N1 78N2 78N3 79N1 79N3 80N2
21.00	-	28.00	(4)	1N1 5N1 20N1 80N3
28.00	-	35.00	(1)	69N2
35.00	-	42.00	(2)	5N1 5N2
42.00	-	49.00	(0)	
49.00	-	56.00	(0)	
56.00	-	63.00	(0)	
63.00	-	70.00	(0)	
70.00	-	77.00	(1)	11N2

EODPRES3

BASELINE TESTS NO 3 FOD PRESSURE (DISCH C/2 TO .75 V/C AT 20 DEG C)
VARIABLE NO. 69 BY MACH.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	35.0000	34.0000	136	12.5735	4.71975

0.	-	3.000	(2)	70N1 73N1
3.000	-	6.000	(4)	9N2 18N1 55N1 63N2
6.000	-	9.000	(19)	4N2 10N2 12N1 12N2 21N2 31N2 38N1 38N2 49N1 49N2 56N1 63N1 65N2 66N1 73N2 76N1 79N2 80N2 82N2
9.000	-	12.00	(30)	7N1 7N2 9N1 13N2 16N2 17N2 18N2 26N1 27N2 28N2 30N1 31N1 34N1 40N1 40N2 53N1 57N1 59N1 59N2 65N3 68N2 68N3 72N2 73N3 74N1 74N2 76N3 77N2 77N3 81N3
12.00	-	15.00	(33)	2N1 4N1 6N2 8N1 10N1 23N1 24N1 24N2 25N2 28N3 33N1 41N2 43N2 50N1 54N2 55N2 56N2 57N2 61N1 65N1 67N1 67N2 67N3 68N1 72N1 74N3 75N1 75N3 76N2 78N2 79N3 80N1 80N3
15.00	-	18.00	(37)	2N2 3N1 3N2 8N2 13N1 14N2 16N1 17N1 23N2 25N1 27N1 29N1 29N2 33N2 34N2 41N1 43N1 50N2 54N1 58N1 58N2 60N1 60N2 61N2 62N1 64N1 64N2 66N2 66N3 70N2 70N3 77N1 78N1 78N3 79N1 81N2 82N1
18.00	-	21.00	(6)	14N1 19N1 19N2 37N1 37N2 75N2
21.00	-	24.00	(1)	69N1
24.00	-	27.00	(3)	6N1 36N1 36N2
27.00	-	30.00	(0)	
30.00	-	33.00	(0)	
33.00	-	36.00	(1)	69N2

EODPRESS

BASELINE TESTS NO 5 EOD PRESSURE (DISCH C/2 TO .75 V/C MATRIX TEMP)

VARIABLE NO. 71 BY PACK,CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
2.00000	40.0000	38.0000	147	15.5442	5.60361

0.	-	3.000	(1)	51N1
3.000	-	6.000	(4)	48N2 53N2 55N1 70N1
6.000	-	9.000	(10)	9N2 12N2 15N1 15N2 46N1 63N2 66N1 71N3 72N3 82N2
9.000	-	12.00	(15)	12N1 18N1 20N2 28N2 31N2 38N2 44N1 49N1 56N1 65N2 68N3 71N2 76N1 76N3 79N2
12.00	-	15.00	(27)	7N1 7N2 16N2 18N2 21N2 28N3 30N1 31N1 38N1 40N2 45N1 46N2 49N2 50N1 51N2 53N1 59N1 59N2 63N1 65N3 67N2 68N2 74N1 74N2 76N2 77N2 77N3
15.00	-	18.00	(42)	2N1 2N2 8N1 8N2 9N1 13N2 16N1 17N2 20N1 22N1 23N1 23N2 24N1 25N2 27N2 29N2 32N1 34N1 35N1 40N1 41N1 41N2 45N2 48N1 50N2 52N2 55N2 56N2 57N1 57N2 58N1 58N2 62N1 65N1 66N3 67N3 68N1 72N2 74N3 79N3 80N2 82N1
18.00	-	21.00	(28)	11N1 13N1 17N1 19N1 19N2 22N2 24N2 25N1 27N1 29N1 35N2 36N1 36N2 39N1 39N2 52N1 61N1 61N2 66N2 69N1 71N1 72N1 75N1 75N3 77N1 78N1 78N2 80N1
21.00	-	24.00	(10)	3N1 3N2 5N1 5N2 34N2 70N3 78N3 79N1 80N3 81N3
24.00	-	27.00	(6)	44N2 47N1 47N2 70N2 75N2 81N2
27.00	-	30.00	(2)	6N1 32N2
30.00	-	33.00	(0)	
33.00	-	36.00	(1)	69N2
36.00	-	39.00	(0)	
39.00	-	42.00	(1)	11N2

EODPRES6 BASELINE TESTS NO 6 EOD PRESSURE (DISCH MATRIX HEAT + TEMP TO .50 V/C)

VARIABLE NO. 72 BY PACK.CELL POSITION

MIN	MAX	RANGE	N	MEAN	STD. DEV.
1.00000	87.0000	86.0000	131	21.5038	15.4155

0.	-	8.000	(11)	9N2 15N1 18N1 21N1 46N1 53N2 70N1 71N3 72N3 77N3 82N2
8.000	-	16.00	(30)	12N1 13N2 15N2 18N2 22N1 25N2 26N1 27N2 30N1 31N1 31N2 32N1 44N1 45N1 46N2 48N2 50N1 51N2 53N1 59N1 59N2 65N1 65N2 65N3 67N2 67N3 71N2 77N2 79N2 82N1
16.00	-	24.00	(58)	7N2 9N1 13N1 16N1 16N2 17N1 17N2 22N2 24N1 24N2 25N1 27N1 28N3 33N1 33N2 34N1 34N2 37N1 37N2 39N1 39N2 40N2 41N1 41N2 43N2 45N2 48N1 50N2 52N1 52N2 54N1 54N2 56N2 58N1 58N2 60N1 60N2 64N1 64N2 66N1 69N1 70N2 70N3 71N1 72N1 72N2 75N2 76N3 77N1 78N1 78N2 79N1 79N3 80N2 80N3 81N1 81N2 81N3
24.00	-	32.00	(15)	2N1 2N2 3N1 3N2 7N1 28N2 32N2 40N1 43N1 44N2 56N1 66N2 66N3 78N3 80N1
32.00	-	40.00	(7)	12N2 21N2 59N2 74N1 74N2 74N3 76N1
40.00	-	48.00	(0)	
48.00	-	56.00	(2)	62N1 63N2
56.00	-	64.00	(3)	6N1 35N2 63N1
64.00	-	72.00	(2)	6N2 35N1
72.00	-	80.00	(0)	
80.00	-	88.00	(3)	75N1 75N2 75N3

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