AF Ni-Cd Cell Qualification Program

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AIR FORCE NI-CD PROGRAM
OVERVIEW OF TEST PROGRAM

PURPOSE

GENERIC QUALIFICATION OF AEROSPACE NICKLE-CADMIUM CELLS

MULTIPLE MANUFACTURES
MULTIPLE DESIGNS
INCLUDES CELLS FROM PREVIOUS PROGRAM
HIGH AND LOW ORBIT LIFE CYCLING

CHARACTERIZE BEGINNING OF LIFE PERFORMANCE
STRESS TEST
6351A

TYPE
50 A/H NI-CD, HUGHES

TEMPERATURE
20 DEGREES CENTIGRADE

ORBIT
100 MINUTES

DISCHARGE
36.0 AMPS FOR 34 MINUTES, 40%DOD

CHARGE
25.0 AMPS WITH V/T TAPER AT V/T 7.5 (1.464 V/C)
6352A

TYPE

50 A/H NI-CD, HUGHES

TEMPERATURE

5 DEGREES CENTIGRADE

ORBIT

96 MINUTES

DISCHARGE

25.0 AMPS FOR 30 MINUTES, 25%DOD

CHARGE

25. AMPS WITH V/T TAPER AT V/T 5.5 (1.458 V/C)
### RECONDITIONED AT SIX MONTH INTERVALS

#### 6352A

**DISCHARGE AT C/2 TO 1.10 VOLT FIRST CELL**

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>A/HO</th>
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<tbody>
<tr>
<td>6</td>
<td>36.3</td>
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<tr>
<td>12</td>
<td>33.8</td>
</tr>
<tr>
<td>18</td>
<td>38.0</td>
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</table>
ANNUAL TRENDPLOT
Pack: 6321H  Manf: HUGHES  21.0 AH
Orbit: LEO  Temp (C): 20  DOD(%): 40.0
Discharge(Amp/Hrs): 15.0/0.56  Charge(Amp/Hrs): 10.5/1.12

TEST DATA AS OF OCTOBER 23, 1993

1. START LIFE-CYCLING, V/T 5.5 (1.424 V/C).
2. CYCLE 1851, V/T INCREASED TO 8.0 (1.434 V/C).
CONCLUSIONS OF RESULTS FOR "SUPER NICD" CELLS

* THERE IS A STORAGE/HANDLING ISSUE
* 50 Ah, 40% DOD PACK HAS INCREASING E0CV DIVERGENCE
* BEGINNING OF LIFE CAPACITY FADE NOT DETRIMENTAL TO CYCLE LIFE
ANNUAL TRENDPLOT

Pack: 63505  Manf: SAFT 50.0 AH
Orbit: LED  Temp (C): 20  DOD(%): 40.0
Discharge(Amp/Hrs): 35.3/0.56  Charge(Amp/Hrs): 25.0/1.12

TEST DATA AS OF OCTOBER 23, 1993

1. START OF LIFE CYCLING, V/T 6.0 (1.434 V/C).
2. CYCLE #775, INCREASED TO V/T 8.5 (1.444 V/C) DUE TO LOW EOD'S.
3. CYCLE #1125, INCREASED TO V/T 7.0 (1.454 V/C) DUE TO LOW EOD'S.
4. CYCLE #1513, INCREASED TO V/T 7.5 (1.464 V/C) DUE TO LOW EOD'S.
5. CYCLE #2020, INCREASED TO V/T 8.0 (1.474 V/C) DUE TO LOW EOD'S.
6. CYCLE #3076, INCREASED TO V/T 8.5 (1.484 V/C) DUE TO LOW EOD'S.
ANNUAL TRENDPLOT
Pack: 6351S  Manf: SAFT  50.0 AH
Orbit: LEO  Temp (°C): 0  DOD(%): 25.0
Discharge(Amp/Hrs): 25.0/0.50  Charge(Amp/Hrs): 25.0/1.10

TEST DATA AS OF OCTOBER 23, 1993

Cells Cycling

1. STARTED LIFE-CYCLING, V/T B (1.480 V/C).
1. Shadow #1, lowered V/L to 1.414 v/c, due to high per-cent recharge.
2. Shadow #1, during Cycle # 25, a system problem occurred that caused the A/Hs to be read as 21,474 A/H. The pack was then recharged with a V/L for 202 hours.
3. Shadow #3, The DOD was adjusted to 80%.
4. Cycle #24, lowered to VT#4 (1.384 v/c) due to cells warming at EOC.
5. Cycle #24, raised to VT#5 (1.404 v/c) due to low EOD. Volts.
6. Cycle #307, lowered to VT#4 (1.384 v/c) due to warming at EOC.
7. Cycle #339, raised to VT#5 (1.404 v/c) due to low EOD. Volts.
8. Cycle #408, started pack using true VT control.
9. Cycle #428, raised to VT#5 (1.414 v/c) due to low EOD.
10. Shadow #24, due to chamber problems, the pack remained in OCV 29 days during Shadow Day #38.
11. Cycle #1087, raised to VT#5 (1.424 v/c) due to low EOD.
1. Shadow #1, VT 5 (1.414 V/C).
2. Shadow #4, DOD changed from 88 to 80 per cent recharge.
3. Shadow #8, VT 4.5 (1.404 V/C) due to cells warming during charge.
4. During Shadow #8, the pack was using a 2 step V/T. The first ten days and the last nine days of the shadow period were at VT 4.0 (1.384 V/C). During days 11 thru 33 (mid-shadow) the pack ran at VT 4.5 (1.404 V/C).
5. Shadow #10, voltage clamp changed to voltage/temperature controlled voltage limit at VT 5 (1.414 V/C).
6. Shadow #20, due to chamber problems, the pack remained in OCV 28 days during Shadow Day #7.
7. Shadow #23, increased to VT 5.5 (1.414 V/C), due to low EOD.
CONCLUSIONS OF RESULTS FOR SAFT CELLS

* C/D HIGHER THAN THAT OF PRE-1986 GATES CELLS
* LEO RESULTS VERIFY GENERIC QUALIFICATION OF V0S A (UP TO 40 Ah) CELLS
* RECOMMEND A NEW TERMINAL DESIGN FOR 40Ah CELLS
TEST DATA AS OF OCTOBER 23, 1993

1. LIFE CYCLING STARTED AT VT 4.0 (1.380 V/C).
2. VT'S WERE INCREASED FROM 4.0 TO 8.0 IN 1/2 VT INCREMENTS DUE TO LOW EOD'S AND % RECHARGE.
3. A PERCENT OF RECHARGE INCREASE WAS NOTICED AFTER EXTENDED OPEN CIRCUIT TIMES DURING CHAMBER PROBLEMS.
4. CYCLE #3840, IT WAS NOTICED THAT ALL CELL CASES WERE SWOLLEN DUE TO HIGH PERCENT OF RECHARGE (117%).
5. CYCLE #6073, PACK SLIGHTLY RECONDITIONED WHEN TEST SYSTEM WENT DOWN. VOLTAGE STEADILY INCREASED THE NEXT 25 CYCLES AND THEN DECLINED.
ANNUAL TRENDPLOT

Pack: 8335B  Manf: GATES  35.0 AH
Orbit: GPS  Temp (C): 20  DOD(%): 41.4
Discharge(Amp/Hrs): 15.8/0.92  Charge(Amp/Hrs): 03.5/9.50

TEST DATA AS OF OCTOBER 23, 1993

1. STARTED LIFE CYCLING AT V/T 4.0(1.380 V/C).
2. V/T'S WERE ADJUSTED FROM 4.0 TO 5.0, IN INCREMENTS OF 1/2 V/T, DUE TO LOW EOD'S.
3. CYCLE #528, PACK WAS RECONDITIONED WITH A/HO 20.12.
4. CYCLE #684, DECREASED TO V/T 4.5(1.404 V/C) DUE TO HIGH EOC TEMP....
5. CYCLE #733, INCREASED TO V/T 5.0(1.414 V/C) DUE TO LOW EOD.
6. CYCLE #862, INCREASED TO V/T 5.5(1.424 V/C) DUE TO LOW EOD.
7. CYCLE #1005, PACK WAS RECONDITIONED WITH A/HO 23.7.
8. CYCLE #1374, INCREASED TO V/T 6.0(1.434 V/C) DUE TO LOW EOD.
9. CYCLE #1506, PACK WAS RECONDITIONED WITH A/HO 23.7.
**STRESS TEST**

**6353G**

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<tr>
<th>TYPE</th>
<th>50 A/H LIGHTWEIGHT NI-CD, GATES</th>
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<tr>
<td>TEMPERATURE</td>
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<td>ORBIT</td>
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<td>DISCHARGE</td>
<td>35.3 AMPS FOR 34 MINUTES, 40%DOD</td>
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<td>CHARGE</td>
<td>25.0 AMPS WITH V/T TAPER AT V/T 6 (1.434 V/C)</td>
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RESULTS FOR GATES CELLS

* 35 Ah CELL, 40% DOD & 20 C: EODV > 0.987 AT 9443 CYCLES

* 35 Ah CELL, 41.4% DOD & 20 C: EODV > 1.094 AT 1495 CYCLES
ACCELERATED 10.4 HOUR GPS ORBIT

* 50 Ah CELL, 40% DOD & 20 C: TESTING JUST BEGAN