50 Ah Ni H2 CELL LIFE TEST RESULTS

by

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HISTORIC

- DEVELOPMENT OF A MEDIUM CAPACITY RANGE (30 - 50 Ah) IPV SAFT Ni H₂ CELL (1985 - 1988)
- SHORT TERM QUALIFICATION TESTING REALISED BY MID 1988

Table 1: Qualification Test Program

- 3 vessels with sleeves
- 6 vessels
- 22 cells
- Fatigue tests
- Burst tests
- Safety tests
- Vibration tests
- Thermal tests
- Life tests
SAFT 50 Ah CELL DESIGN (VHS BL SERIE)

MECHANICAL/VESSLE DESIGN

- PRESSURE VESSEL MADE OF HEAT TREATED INCONEL 718 PARTS.
- VESSEL DIAMETER IS 3.2 INCHES AND OVERALL LENGTH IS 8 INCHES.
- WALL THICKNESS IS 0.024 INCHES.
- TERMINALS: BRAZED CERAMIC FEED THROUGH. "RABBIT EAR POSITION"
- FILLING TUBE: HARDENED INCONEL (1 TERMINALS PLAN)
- TIG WELDING TECHNIQUE FOR ALL JONCTIONS.
- MOP: 1070 PSI/SAFETY FACTOR: 2.5.
SAFT 50 Ah CELL DESIGN

(VHS BL SERIE)
SAFT 50 Ah CELL DESIGN (VHS BL SERIE)

ELECTROCHEMICAL/STACK DESIGN

GENERAL
- BACK TO BACK CONFIGURATION/MONO STACK.
- CENTRAL TIE ROD/EXTERNAL CONT. LEAD ASSEMBLY
- RIGID END PLATES/EXPANSION SYSTEM
- REDUCED STACK/WALL GAP.

POSITIVE ELECTRODE
- POROUS NICKEL SINTER (OPTIMIZED POROSITY).
- IEC ACTIVE MATERIAL (APPROPRIATE LOADING).

NEGATIVE ELECTRODE
- CURRENT COLLECTOR: EXPANDED NICKEL GRID.
- CATALYST: PT CHARCOAL + TEFLOMISED BINDER.
- HYDROPHOBIC BACK LAYER: MICROPOROUS PTFE.
SAFT 50 Ah CELL DESIGN (VHS BL SERIE)

ELECTROCHEMICAL/STACK DESIGN (suite)

SEPARATOR
- MULTILAYERED NON WOVEN POLYAMID FELT.

GAS - SCREEN
- WOVEN NYLON MATERIAL.

ELECTROLYTE
- 31 % w KOH (BEFORE ACTIVATION)

THERMAL DESIGN

SINGLE PIECE SLEEVE TO BASEPLATE
- LIGHT AL ALLOY.

GAP INTERFILLER
- POLYMERIC RESIN.
SAFT 50 Ah CELL DESIGN (VHS BL SERIE)

ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>CAPACITY</th>
<th>51.5 Ah</th>
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<tbody>
<tr>
<td>ENERGY DENSITY</td>
<td>48 Wh/Kg</td>
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<tr>
<td>VOLUMIC ENERGY</td>
<td>70 Wh/L</td>
</tr>
<tr>
<td>INTERNAL RESISTANCE</td>
<td>&lt; 3 mΩ</td>
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MEAN VALUES ON THE QUALIFICATION LOT.

Available Capacity
SAFT 50 Ah CELL LIFE TEST

PURPOSE

- TO PERFORM AN ACCELERATED GEO LIFE TEST.
- TO STUDY SENSITIVITY TO MANAGEMENT PARAMETERS.
- TO ASSESS THE EFFECT OF RECONDITIONNING.

OBJECTIVE

- TO EVALUATE LONG TERM ABILITY OF THE DESIGN.
- TO DEMONSTRATE AT LEAST 10 YEARS OF OPERATION.

SCHEDULE

- START UP JULY 1988
- END SEPTEMBER 1991
SAFT 50 AH CELL LIFE TEST

TEST CELLS AND APPARATUS

- NINE CELLS TAKEN FROM THE QUALIFICATION BATCH (1/3 VIBRATED).
- COMPACT INDIVIDUAL SLEEVE MOUNTING ON A COLD PLATE (VERTICAL).
- THERMAL BLANKET TO LIMIT CONVECTION EXCHANGE.
- SAFETY DEVICES (TEMPERATURE CONTROLLER, HYDROGEN DETECTOR, ETC...).
- ANTI DEFLEGRATING CHAMBER.
- Reference Temperature 10°C
- C/200 - C/100
- Regen
- 1.15 - 1.17
- Return Factor
- C/14
- Charge Regen
- 70%
- DOD
- C/1.7
- Discharge Regen

LIFE TEST PARAMETERS

- Reconditioning + Standard Capacity Measurement.
- Reduced Solstice Simulation.
- 12 Hours Simulated Eclipse Period.
- Real Time Eclipse Profile with 72 Minutes Maximum Discharge Time.
- 45 Cycles Eclipse Season.

GEAR CYCLING CONDITIONS - GENERAL

SALT 50 AH CELL LIFE TEST

CUES
SAFT 50 Ah CELL LIFE TEST

RESULTS

DISCHARGE VOLTAGE EVOLUTION

- STABILITY FOR MEAN DISCHARGE VOLTAGE (1.26 V).
- SLIGHT DECREASE FOR EOD VOLTAGE: 1.16 V/EOL.

![Graph showing discharge voltage evolution over time](graph.png)
SAFT 50 Ah CELL LIFE TEST RESULTS

END OF CHARGE VOLTAGE EVOLUTION

- NO APPARENT DEGRADATION (1.5 V)
SAFT 50 Ah CELL LIFE TEST RESULTS

END OF CHARGE PRESSURE EVOLUTION REFERENCE CYCLE

- NO PRESSURE STABILITY ALONG THE WHOLE TEST.
- AT MAXIMUM CYCLING PRESSURE ΔP IS 4 BARS.
SAFT 50 Ah CELL LIFE TEST RESULTS

STANDARD CAPACITY MEASUREMENT

- AFTER : CC ON A RESISTANCE (16 H).
- CHARGE AT C/5 WITH A CHARGE RATIO OF 1.54.
- OPEN CIRCUIT DURING 1 HOUR.
- DISCHARGE WITH TWO STEPS.
   - C/2 TO 1 V
   - C/5 TO 0.5 V
- ALL OPERATIONS AT 10°C.
SAFT 50 Ah CELL LIFE TEST RESULTS

STANDARD CAPACITY MEASUREMENT

- OVERALL CAPACITY REMAINS VERY STABLE.
- SLIGHT STANDARD CAPACITY FADING (54 ---> 49 Ah)

WITH CORRESPONDING RESIDUAL INCREASE.
SAFT 50 Ah CELL LIFE TEST RESULTS

COMPARISON BETWEEN ON CYCLE AVAILABLE CAPACITY

AND STANDARD CAPACITY

- CAPACITY AT 1 V UNDER CYCLING DISCHARGE REGIM REPRESENTS 80 TO 95 % (WRT STANDARD CAPACITY).

- DEPENDS ON STATE OF CHARGE (AND K VALUE, FLOATING REGIM, TEMPERATURE).
SAFT 50 Ah CELL LIFE TEST RESULTS

COULOMBIC EFFICIENCY EVOLUTION FOR REFERENCE CYCLE

- SMALL DISCHARGE EFFICIENCY DIMINUTION/TO COUPLE WITH MAX PRESSURE EVOLUTION.
SAFT 50 Ah CELL LIFE TEST RESULTS

CONSTANT POWER DISCHARGE EFFECT AND TRICKLE CHARGE EFFECT

- ON SEASONS 29 TO 31 CELLS WERE SPLITTED ON 3 GROUPS.
  . STD CYCLING (FOLLOW ON) 3 CELLS.
  . CONSTANT POWER DISCHARGE 3 CELLS
  . TRICKLE CHARGE : CONTINUOUS C/90 FOR TWO MONTHS 2 CELLS

- ONE CELL OUT OF SERVICE (SHORT CIRCUIT) DUE TO TEST ERROR AND INSULATION FAILURE.
SAFT 50 Ah CELL LIFE TEST RESULTS

COMPARISON BETWEEN CONSTANT CURRENT AND CONSTANT POWER DISCHARGE

SEASON 31, CYCLE 23.

- DISCHARGE VOLTAGE AT P ct IS HIGHER THAN AT I ct.
- EOD VOLTAGES ARE IDENTICAL.
- CURRENT IS 10 % HIGHER (WRT I CT) AT END OF DISCHARGE.
SAFT 50 Ah CELL LIFE TEST RESULTS

RECONDITIONNING EFFECT

- CELL 9 WASN'T RECONDITIONNED AFTER SEASON 26.
- DIRECT EFFECT IS OBSERVED ON SEASON 27.
SAFT 50 Ah CELL LIFE TEST RESULTS

TEMPERATURE EVOLUTION

- CONDUCTION GRADIENT BETWEEN CELL/SLEEVE WALL AND BASEPLATE ARE SLIGHTLY RISING AS AN AGEING EFFECT WITH CYCLES.
SAFT 50 Ah CELL LIFE TEST RESULTS

EOD CURRENT PROFILE (POWER ct) SEASON 29

ASYMMETRIC CURVE WITH MAXIMUM AT CYCLE 30.
SAFT 50 Ah CELL LIFE TEST RESULTS

TRICKLE CHARGE EFFECT

- CONTINUOUS CHARGE AT C/90 ENHANCE STATE OF CHARGE.

- AS DIRECT RESULT ON CYCLE DISCHARGE CAPACITY IS IMPROVED (50 Ah VERSUS 47 Ah) BUT STD CAPACITY ISN'T AFFECTED.

- DISCHARGE VOLTAGES ON SEASON 31 (AFTER TWO MONTHS OF TRICKLE) ARE 10 mV HIGHER/Cells WITHOUT TRICKLE.
SAFT 50 Ah CELL TEST RESULTS

SUMMARY

- 33 ECLIPSE SEASONS COMPLETED AND MORE THAN 3 YEARS OF CYCLING REALISED.
- RECONDITIONNING IS MANDATORY TO INSURE SATISFACTORY EOD VOLTAGES.
- AVERAGE EOD VOLTAGES NEVER SLOW DOWN 1.16 V/CELL.
- REAL DOD NEVER EXCESS 73 % / CAPACITY FAADING ENCOUNTERED.
- NO ELECTRICAL LIMITATIONS WITH CONSTANT POWER DISCHARGE.

ADDITIVES

- DPA RUN ON FAILED CELL.
- EXTENSIVE CHARACTERIZATION PROGRAMM IS SET UP AND WILL BE RUN SOON.

IMPLEMENTED DATA

- AN OTHER LIFE TEST HELD AT AEROSPATIALE (20 SEASONS PLANNED).
  nine 50 Ah SAFT CELLS.
  70 % DoD ; 10°C ; REAL TIME ECLIPSE ; K = 1.12 ;
AFTER 9 SEASONS RESULTS ARE VERY SIMILAR.
SAFT 50 Ah CELL LIFE TEST

CONCLUSIONS

EXPECTED GOAL, (10 YEARS) LARGELY COMPLETED IN EXCESS.

- VHS BL SERIE EXHIBIT A GOOD BEHAVIOUR.

- THIS TECHNOLOGY AUTHORIZED MORE THAN 15 YEARS AT 70 % DoD AND 10°C ON ACCELERATED TESTING.

NEXT STEP WILL CONSIST ON A LIFE TEST TO PERFORM ON 20 VHS 90 CM SAFT CELLS.

- LIFE TEST AT BTC/ESA/ESTEC.


- FIVE YEARS LIFE TEST.