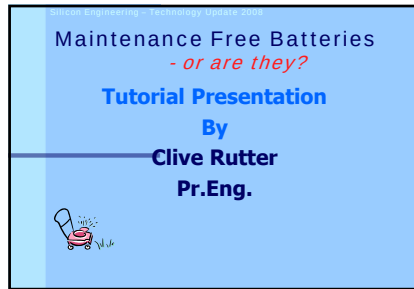
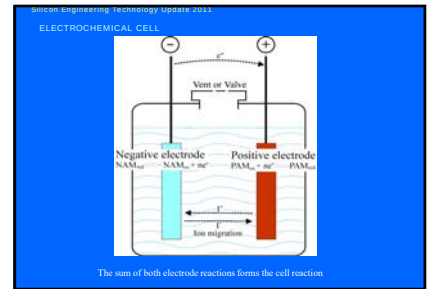




1



2



3

Energy Content of Chemical Reactions

Generated energy (entropy of reaction):
Energy content of the products minus that of the reactants

Example:
 Oxidation (burning) of carbon:
 $C + O_2 \rightarrow CO_2$

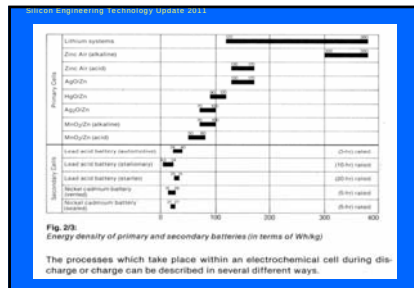
Element	C	O ₂	CO ₂
Energy of formation ΔH_f in kcal/mole	0	0	-94.05

Entropy of reaction $\Delta H = \Delta H_f(CO_2) - [\Delta H_f(C) + \Delta H_f(O_2)]$

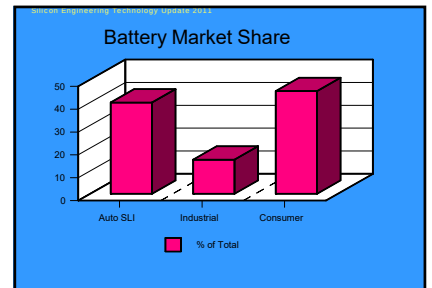
Entropy of reaction: -94.05 kcal/mole = 393.7 kJ/mole or W/mole
 = 109.4 Wh/mole

Molar mass of C + O₂ or CO₂: 44 g/mole⁻¹
 Energy generation related to this weight: 2.49 kWh/kg
 Molar mass of C: 12.01 g/mole
 Energy generation related to Carbon: 9.12 kWh/kg

4



5



6

Automotive Batteries (SLI)

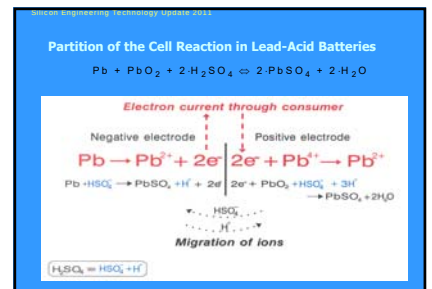
If the average SLI battery has a life of 3 years then:
The world vehicle population now exceeds 1 Billion and world replacement market is 330 million per annum.
The South African replacement market should be 3,3 million per annum.

7

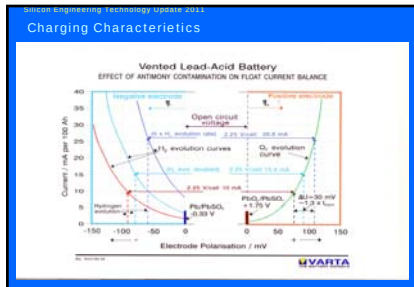
Lead Acid Basics

- Pos Discharge Lead Dioxide=> Lead Sulphate
- Neg Lead =>Lead Sulphate
- Oxygen Evolution at POSITIVE plate
- Hydrogen Evolution at NEGATIVE plate
- H₂O Decomposition at 1,23V
- The Oxygen Cycle
- Secondary Reactions

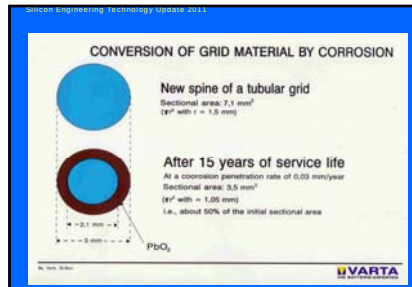
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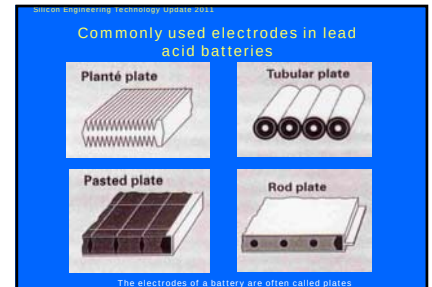
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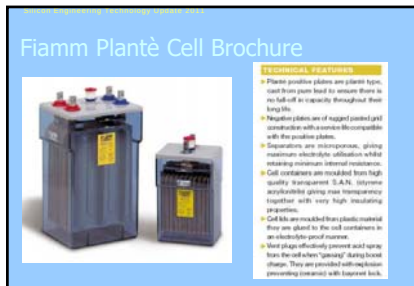
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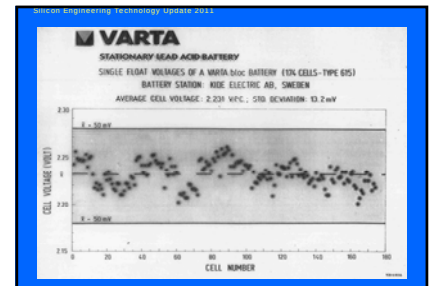


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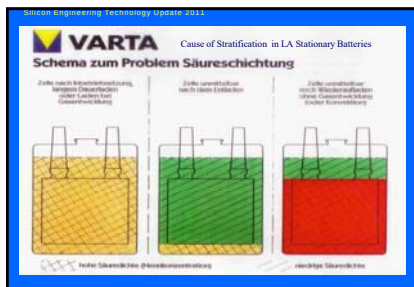
Tubular cells BAE SECURA OP2S - CELL

- Standard: DIN 40736 part 1
- Capacity range: 210 to 3380Ah
- Life time: 16 years +
- IEC 896-1 - cycles: 1500
- Acid density: 1.24kg/l
- Watering interval: 3-5 years
- Ventilation requirement: 50% red. PbSb1.6Se
- Pillar bushing: 100% tight
- Connectors: flexible, fully insulated, bolted
- Jars out of SAN: transparent and rigid (no bulging)

14



15



16

HYDROGEN EVOLUTION IN LA BATTERIES

Per Cell Values

Float Voltage	Float Current	Corresponds to H ₂ per hour
Lead Acid 2.21 V/C	10 to 40mA per 100 AH/cell	4.5 to 18mL 0.1 to 0.4L/day
Nickel Cadmium 1.45 V/C	20 to 50 mA per 100AH/cell	9 to 23 mL 0.2 to 0.5L/day

17

HYDROGEN EVOLUTION IN LA BATTERIES

110V Battery Values

Type	Litres H ₂ /hour	Litres H ₂ /day
Lead Acid	0.1 to 1.6	12 to 39
Nickel Cadmium	0.8 to 2.0	19 to 47

- NiCd, Plante & Pb-Calcium gas evolution approximately constant
- Low Antimony gassing increases to less than double over life
- Low antimony therefore does not exceed NiCd gas significantly
- High Sb (9% Sb) gassing increases by 5 to 10 times over life of 6 to 10 years.

18



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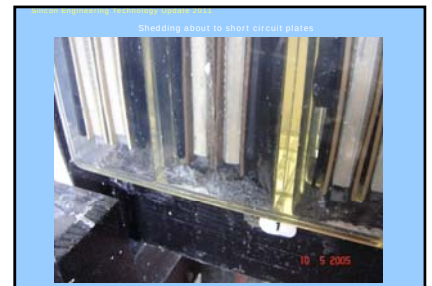
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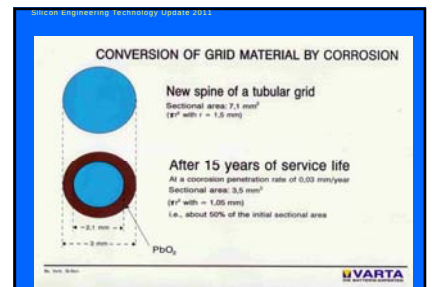
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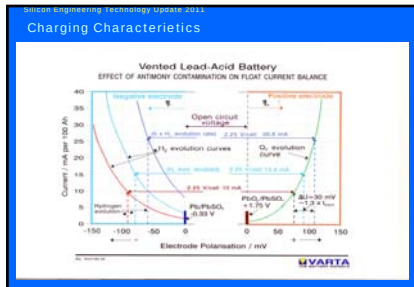
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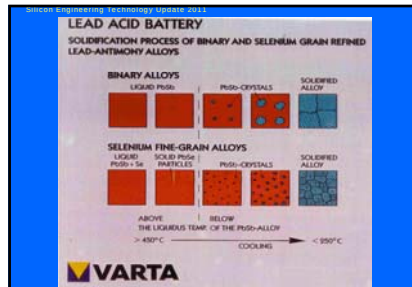
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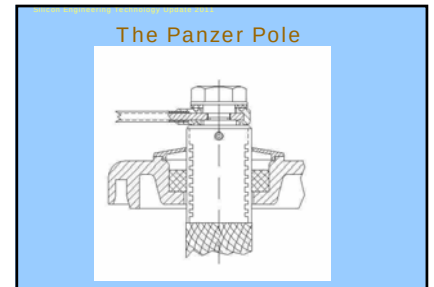
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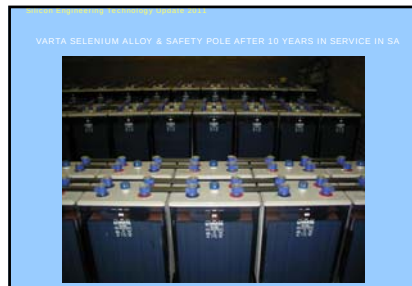
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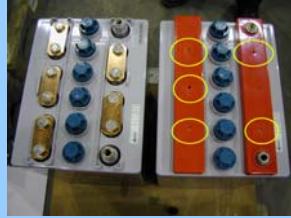
36

The Panzer Pole



37

EACH PANZERPOLE IS CONNECTED ON TOP OF THE BATTERY
THIS REMOVES THE POSSIBILITY OF EXPLOSIONS DUE TO INTER-CELL CORROSION



38

Substation BAE batteries for a Major SA Municipality



39

BAE (BERLIN) LOW ANTIMONY WITH PANZER POLE AT A SA STEEL MILL



40

BAE (BERLIN) BATTERY IN A CRITICAL UPS APPLICATION AT SA OIL REFINERY



41

BAE 150AH BATTERY IN BMS 110V 40A CHARGER



MAINTENANCE
=
WATER TOP UP
ONCE EVERY 3
YEARS

42

INSTALLING BAE BATTERIES & BMS INTEGRAL CHARGER AT A SA
PANZER MILL



43

valve engineering technology update 2007

YES WE'RE
OPEN



The Preacher needs a wee break
Please be Back in five
NEXT "VALVE REGULATED LEAD ACID
BATTERIES VRLA"

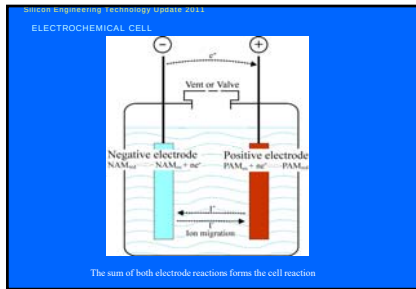
44

Valve Regulated Lead Acid VRLA

- Principle of Operation
- Hydrogen Evolution
- Corrosion of Positive Grid
- AGM Technology
- Gel Technology
- Alloys and Impurities
- Life Expectancy
- Temperature Effects



45



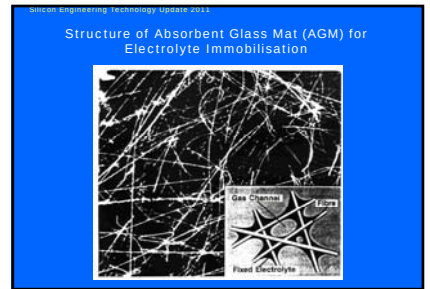
46

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How to 'seal' a lead acid battery

1. Oxygen migrates at 10,000,000 times the speed in air as compared with the speed in electrolyte.
2. If the Oxygen is allowed to migrate quickly from the positive electrode to the negative, then it can recombine with the hydrogen and no water will be lost to the cell.
3. For this to happen, limited amount of acid must be present in the cell.
4. Glass fibre is used to support the acid by capillary action and we have an absorbent glass fibre or AGM type of cell.
5. Alternatively, SiO₂ can be added to the acid to form a jelly or gel and on curing it cracks and allows air paths between the plates. We now have a GEL battery.
6. Corrosion occurs in any lead acid battery and this process uses oxygen which it obtains from the electrolyte H₂O. This leaves hydrogen which builds up pressure and is allowed to escape via a pressure valve. We have a valve regulated lead acid battery VRLA.

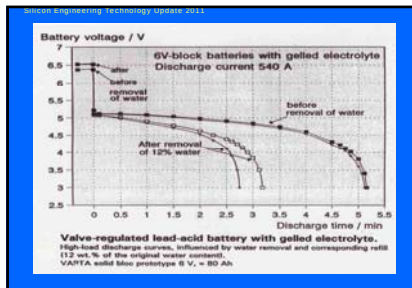
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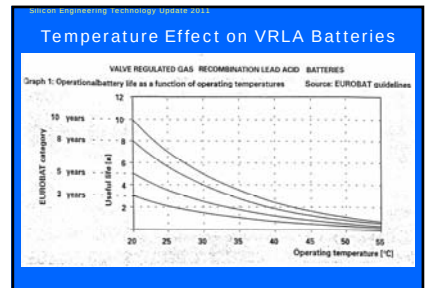
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49



50



51

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Valve Regulated Lead Acid Costs

Material	% of Total Material Cost
Lead Grid, Top Lead	21
Oxides, Additives	27
Separator	13
Electrolyte	16
Box/lid	23
Total	100

52

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The Preacher needs a break
 Please be Back in Ten
 NEXT "Solar Batteries"

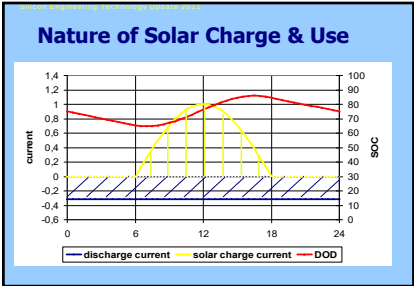
53

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CHARACTERISTICS OF BATTERIES FOR SOLAR APPLICATIONS

Peter Zuehlisdorf, Dr. Wieland Rusch - BAE Batterien GmbH

54



55

- ### REQUIREMENTS OF SOLAR BATTERIES
- 5 - 10 years operational life at 25°C average
 - 1500 to 3000 cycles with 10% to 30% DOD
 - High Ah- and Wh-efficiency
 - Good charge acceptance
 - No topping-up water
 - High integrity (no excessive bulging, no cracks)
 - High insulation value (100% tight pole bushing)

56

- ### CYCLE TEST IEC 61 427-1
- Discharges of 30% DOD
 - Regime 1: Discharges between 40% and 10% SOC
 - Regime 2: Discharges between 60% and 30% SOC
 - Regime 3: Discharges between 100% and 70% SOC
 - Regime 5: mixture of Regime 2 and Regime 3
- Charging factor: 1.01 to 1.02,
Charging restricted to 2.40V/cell

57

ACCELERATED LIFE TIME TEST

ARRHENIUS EQUATION

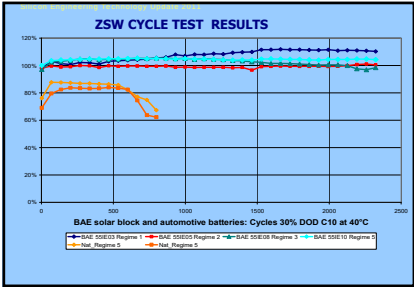
$$t_1 = t_2 \cdot \left[\exp(E/RT_1) / \exp(E/RT_2) \right]$$

What are the requirements at 62.8°C?
Arrhenius law applied: Activation energy of 15.650 cal/mol
350 days at 60°C equals **290 days** at 62.8°C.

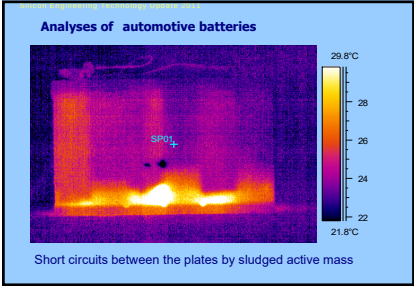
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62

SOLAR BATTERIES

VLA flat	VLA tub	VRLA flat GEL	VRLA tub GEL	VRLA AGM
-	+	++	+++	+

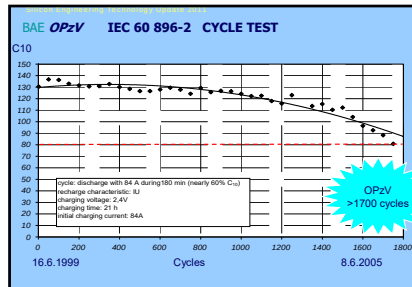
VRLA flat GEL:
Solar block batteries 12V GIV 50Ah₁₀₀ to 6V GIV 250Ah₁₀₀

VRLA tubular GEL
Solar cells 2V 4 OPzV 200 to 2V 24 OPzV 3000

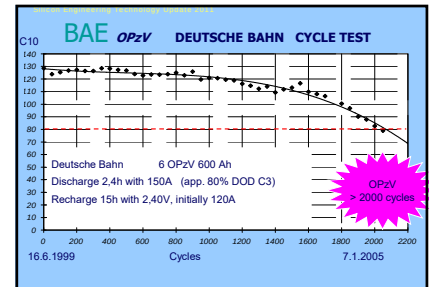
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66

IEC 60 896-22: Life time test
IEC 60 896-22: Stationary Lead-Acid Batteries
Valve-regulated types - Requirements
§ 4.15/16 Required life times

High temperature	40°C	55°C	60°C
Brief duration	500 days	150 days	105 days
Medium duration	750 days	250 days	175 days
Long duration	1100 days	350 days	250 days
Very long duration	1700 days 4.7 years	500 days	350 days

What are the requirements at 62,8°C?
Arrhenius law applied: Activation energy of 15.650 cal/mol
350 days at 60°C equals 290 days at 62,8°C.

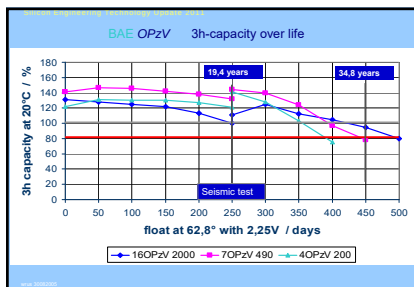
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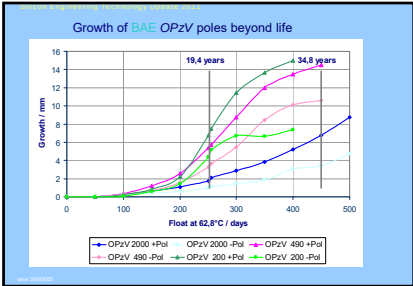
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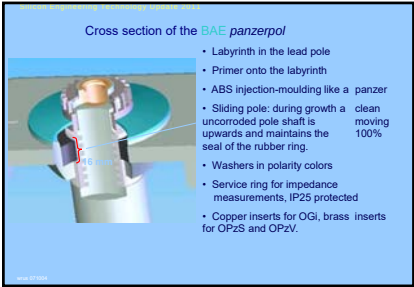
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74



75



76

BAE OPzV: Evaluation of the life time results

IEC 60 896 2.2 requires		BAE OPzV
High temperature exposure		Test result
• brief	105 days at 60°C	450 days at 62,8°C 155% of 290 days
• medium	175 days at 60°C	
• long	250 days at 60°C	
• very long	350 days at 60°C	
290 days at 62,8°C		

77

ACCELERATED LIFE TIME TEST
ARRHENIUS EQUATION

$t_2 = 450 \text{ days}$, $T_2 = 62,8^\circ\text{C}$, $E = 15.280 \text{ cal/mole}$

$t_1 = t_2 \cdot [\exp(E/RT_1) / \exp(E/RT_2)]$

Temperature	IEC 60896-22 very long duration	BAE OPzV
60°C	350 days	545 days
40°C	4,7 years	6,5 years
35°C		9,7 years
30°C		14,7 years
25°C		22,4 years

78



79



80



81



82

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YES WE'RE
OPEN

A Break is coming in a few minutes
Please be patient
NEXT "Automotive SLI Batteries"

83

SLI BATTERIES - STARTER LIGHTS IGNITION

- Old high Antimony (Sb) types required water top up every petrol refill.
- Low Sb (<2% wt) Pos and Sb free Neg removed need for top up throughout life.
- Service life 2 to 5 years depending on environment.
- Low price, low mass, low maintenance.
- Future 18 cell (36V) SLI battery possible.

84



85

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WHY ONE SHOULD BE AWARE WHEN USING SLI BATTERIES ON CRITICAL STANDBY APPLICATIONS

- SLI are designed for Cold Cranking Current and AH capacity is not in the design specification.
- The design life is generally 3 years in an automotive environment. This means 500 hours per annum average. In a UPS type use the float is for 8760 hours (365 x 24). Corrosion is 18 times design value. Actual Life will be reduced.

86

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WHY ONE SHOULD BE AWARE WHEN USING SLI BATTERIES ON CRITICAL STANDBY APPLICATIONS - 2

- The end of life of an SLI battery is when it cannot start the engine (about zero capacity). Standby limit is > 80%.
- The SLI design spec is (a) Low cost (b) Low mass (c) Low volume. (d) 3 year life. Reliability is desirable but not always critical.
- The green eye-piece only monitors one cell and gives approximate indication when capacity <40%.
- They should not be applied where failure could cause loss of life or loss of critical plant.

87

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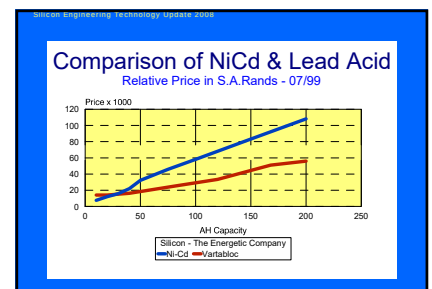
The Preacher needs a break
Please be Back in Ten Minutes
NEXT "Nickel Cadmium Batteries"

88

Nickel Cadmium Basics

- Charge process
- Construction of (a) Pocket Plates (b) Sintered plates (c) Fibre Plates (d) Pressed Powder (e) Plastic-Bonded.
- Corrosion in the cell
- Secondary reactions
- Complete Sealing possible
- Recently applied to Telecommunications.
- Price

89



90

Siemens Engineering Technology update 2008

Pocket Plate Nickel Cadmium Construction

1. Robust mechanical construction
2. Pos and Neg plates look physically alike.
3. They are colour coded in production with paint.

Fig. 1 Pocket plate

91

Siemens Engineering Technology update 2008

Nickel Cadmium Charging & Discharging Process

oxidized ← → reduced

high charged level medium charged level discharged

Hydrogen-oxygen electrolyte: Charge and discharge of the nickel hydroxide electrode with simultaneous release and absorption of pressure 811" noted.

92

Characteristic Features of Ni/Cd Batteries

The electrolyte does not participate in the cell reaction. Consequences are:
The electrodes can be spaced quite narrow (high specific power).
The concentration of the electrolyte remains constant (no freezing)

Nickel does (almost) not corrode at the comparatively low potential of the positive electrode. Consequences are:
Electrode substrates can be very thin and designed in many variations

The equilibrium potential of the cadmium electrode is more positive than the potential of the hydrogen electrode.
Self-discharge by hydrogen evolution does not occur

93

NICKEL CADMIUM POCKET PLATE AND VRPP FROM SILICON

94

Features

- Unsurpassed resistance to electrical and mechanical abuse
- Exceptionally long and reliable service life
- Adaptability to wide temperature range
- No emission of corrosive gases
- Explosion proof
- Minimal maintenance
- Low life time cost
- Quick recharging

95

SY30 Cabinet with 10 to 17 AH Nickel Cadmium Cells

96

SILICON NICKEL CADMIUM CELLS & BMS CHARGER ON A SA GOLD MINE

97

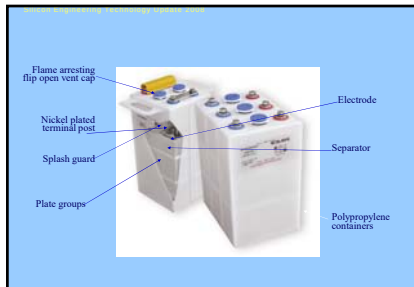
SILICON NICKEL CADMIUM BATTERY IN SERVICE IN A SA REFINERY

98

Valve regulated Nickel cadmium Pocket plate (VRPP)

Low maintenance Nickel Cadmium cells

99



100



101



102

Recombination cycle

At the positive plate
 $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ (oxygen evolution)

At the negative plate
 $2H_2O + 4e^- \rightarrow 4OH^- + 2H_2$ (hydrogen evolution)

The VRPP battery has excess cadmium active material to ensure oxygen evolution commences prior to the hydrogen evolution. The oxygen produced at the positive surface is collected by the separator and recombination takes place when hydrogen is evolved

$$H_2 + 1/2O_2 \rightarrow H_2O$$

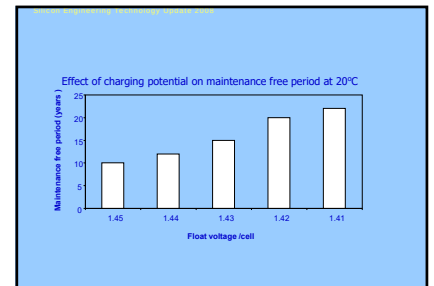
The nature of vent cap facilitates the recombination of gases

103

Benefits of VRPP cells

- Exceptional long life
- Low maintenance
- Wide operating temperature
- Resistance electrical and mechanical abuse

104



105

Do Not Charge VRPP at high Voltage or else they swell up due to internal pressure

106

Maintenance Free ?? Not quite

107

Nickel Metal Hydride

Nickel + Cadmium $\xrightarrow{\text{Cadmium is highly toxic}}$ Nickel + Hydrogen

Nickel + (Rare Earth) Metal + Hydrogen = NiMH

Rare Earth Metal $\rightarrow H_2$

108

Simon Engineering Technology Update 2008

Nickel/Cadmium – Nickel/Hydrogen Batteries

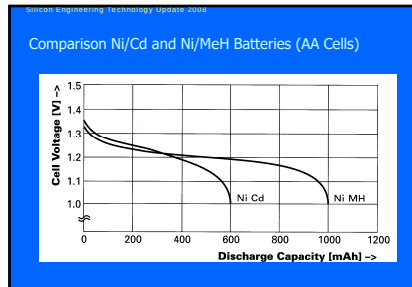
Both system use the nickel/nickel hydroxide electrode as positive electrode

In nickel/cadmium batteries cadmium forms the negative electrode

In nickel/hydrogen batteries hydrogen forms the negative electrode. In the charged state, gaseous hydrogen is stored under high pressure

In nickel/metal hydride batteries hydrogen forms the negative electrode. In the charged state, hydrogen is absorbed in special alloys as a hydride

109



110

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YES WE'RE
OPEN

WELCOME TO THE
TOTAL EXPERIENCE

THE END IS NEAR

111

UPS BATTERIES
Uninterruptible Power Supplies

- Power range 250va – 2500kva
- Backup Times 10 minutes to 10 hours
- Battery Sizing made on Constant Power discharge curves
- Five hour backup UPS can have 80% of price in battery.
- Small UPS often designed about the battery.
- VRLA is preferred technology but SLI batteries often used due to price.

112

SILICON HAS ALL THE CHARGERS TO GO WITH THE BATTERIES
MADE AND SUPPORTED IN SOUTH AFRICA

113

Simon Engineering Technology Update 2008

Thank You for your Attendance

From Silicon Engineering

The End

114