Battery Performance, Technology and Applications

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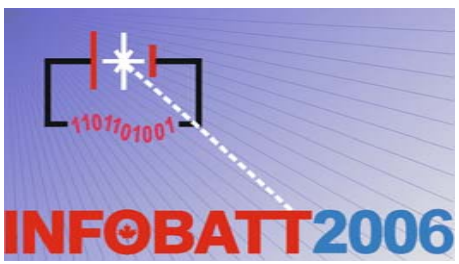

September 24 - 26, 2006

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Discussion Outline.

- » Stationary Battery Applications
- » Stationary Battery Types
- » Which Battery.
- » What Else?
- » Where Do Go From Here?

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What Applications Should We Cover?

There are many applications for Stationary Batteries.

We will try to cover most of them and address them roughly in order of the quantity of battery usage.

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Battery Selection is Application Specific.

Has This Guy Got It Right?

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What Applications Should We Cover?

- UPS
- Telecom
- Broadband
- Switchgear
- Energy Storage
- Industrial
- Engine Cranking
- Other?

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What Applications Should We Cover?

UPS

- UPS Ride Through (Less than 2 Minutes)
- UPS Short Duration (2 – 30 Minutes)
- UPS Long Duration (More than 30 Minutes)

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What Applications Should We Cover?

Telecommunications.

- Fixed (wire line), Short Duration (< 1 hour)
- Fixed, Long Duration >1 hour)
- Wireless (mobile), Short Duration < 1 hour)
- Wireless, Long Duration (> 1 hour)

What Applications Should We Cover?

Broadband (Cable)

- Head End (Indoor)
  - Voice Gateway
  - Data Gateway
  - CATV Up Converter
  - VoIP
- Network (Outdoor)
  - Bi-directional Amplifiers

What Applications Should We Cover?

Switchgear

- Turbines
- Emergency Lighting
- Oil Pumps
- Switchgear

What Applications Should We Cover?

Industrial

- Emergency Lighting
- Alarm Systems
- Process Control
- Public Safety

What Applications Should We Cover?

Energy Storage

- Photovoltaic
- Load Leveling
- Ride-through

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What Applications Should We Cover?

Engine Starting?

Not in this Conference.

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What Should We Consider?

What needs to be taken into account when selecting a battery?

What Should We Consider?

- Voltage
- Discharge Time
- Recharge Time
- Charging Regime
- Cycle or Standby Service
- Life Span
- End of Life Criteria
- Parallel (multiple) Strings
- Battery Type
- Battery Chemistry

What Else Should We Consider?

- Location
- Environment (climate)
- Code Requirements
- Spill Containment
- Physical Protection
- Ancillary Equipment
- Racking/Cabinets
- Installation
- Maintenance
- External factors
- Support Systems

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Comparison of Two Main Technologies

	Lead-Acid	Ni-Cad
Cost	Moderate	High
Reliability	Low to High	Moderate to High
Maintenance	Moderate to High	Low to Moderate
Life	Low to High	Moderate to High
Safety	Low to High	Low to High
Ruggedness	Low to Moderate	Moderate to High
Disposal	Relatively Simple	Can be an Issue

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Types of Lead-Acid Stationary Batteries

- Flat Pasted
- Conical (Round) pasted
- Tubular

Various Lead Alloys Used

- Pure Lead (Planté)
- Lead-calcium
- Lead-antimony
- Lead-selenium (Low Antimony with a slight amount of Selenium

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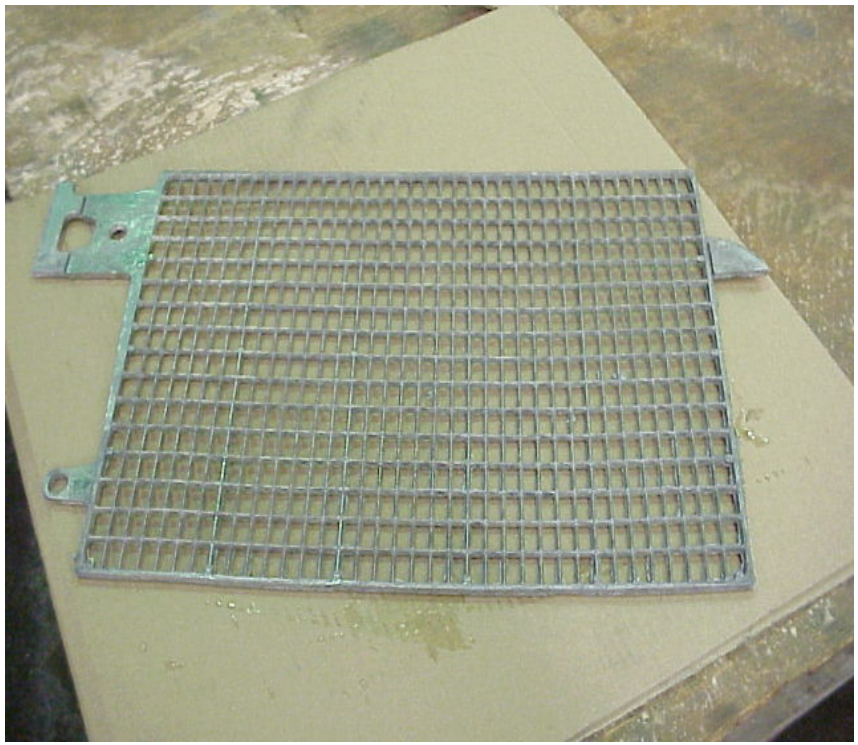
Pasted Plates



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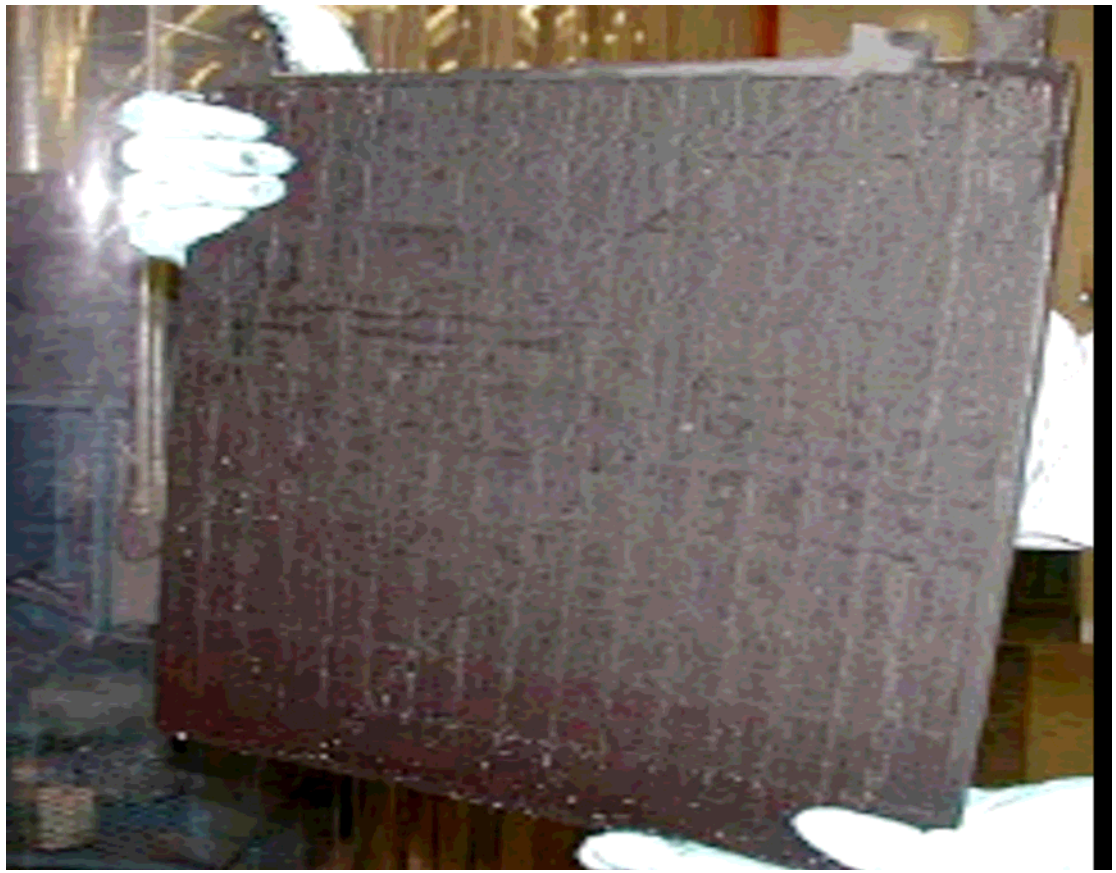

Pasted Plate

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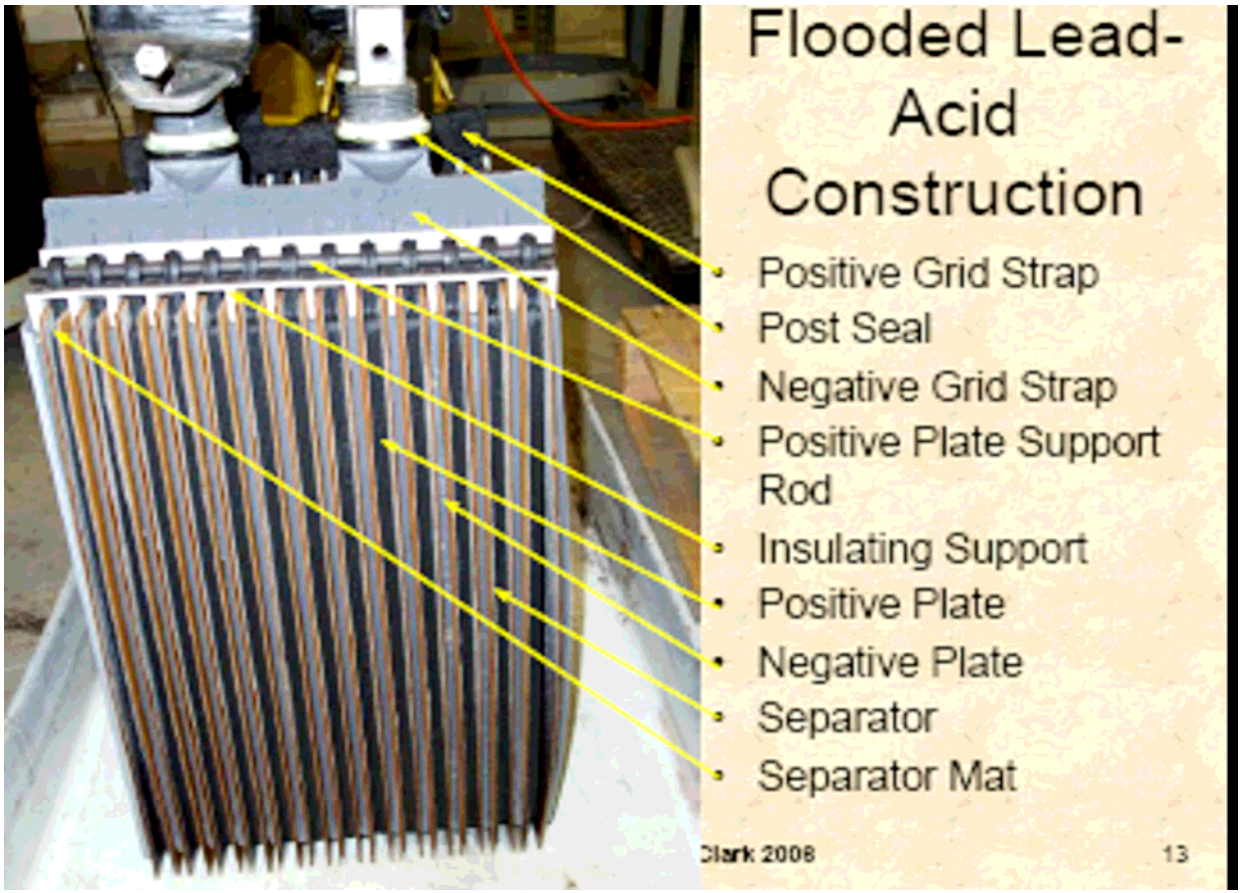

Courtesy of Mark Steven Clark.

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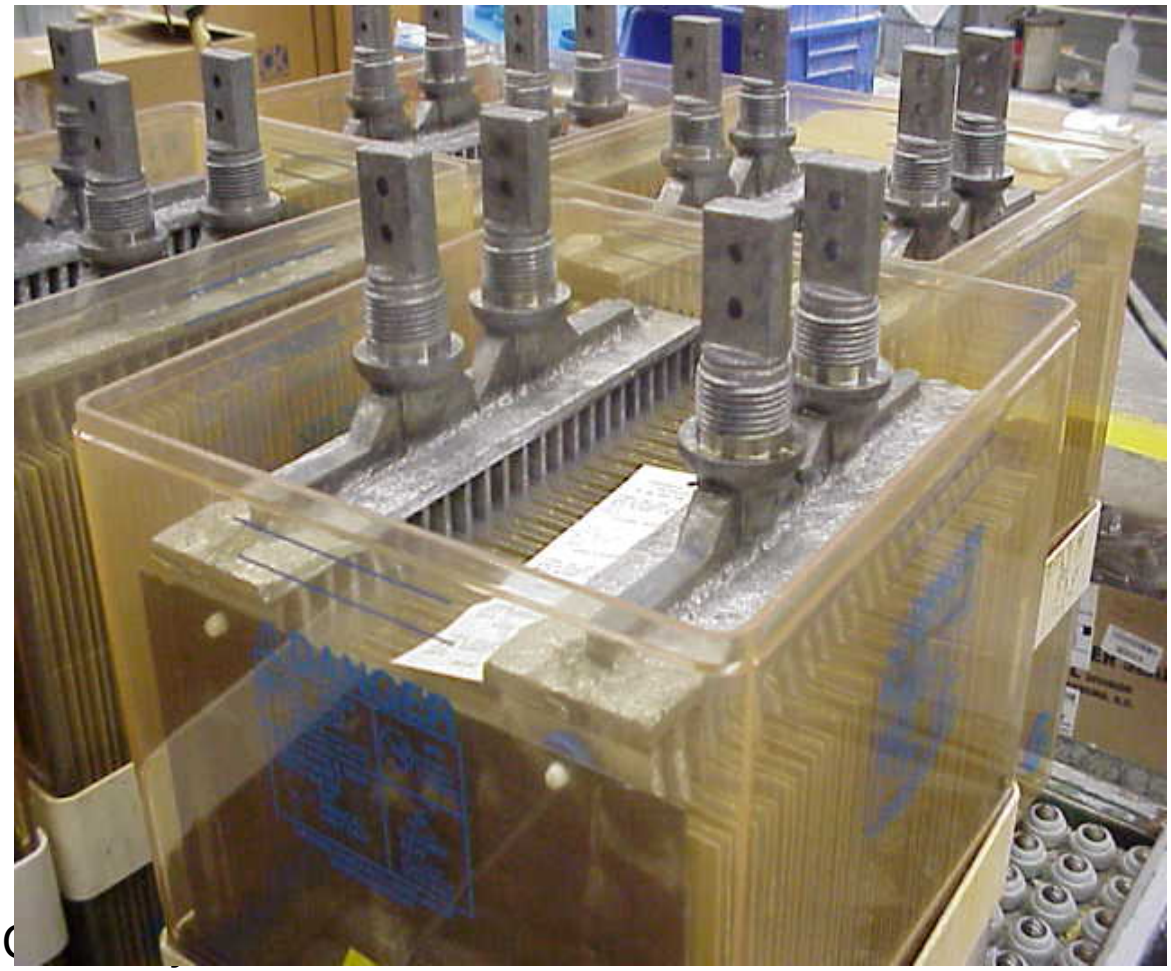

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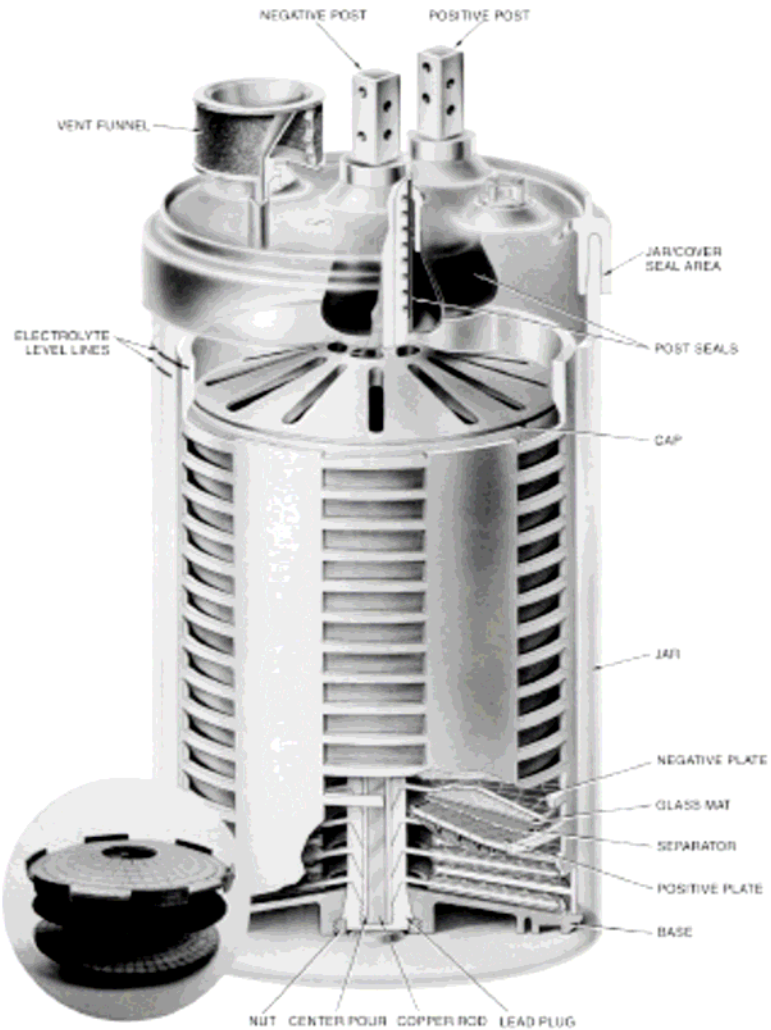

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Tubular Plates

Positive electrodes in porous tubular sheaths.

Long finned spines.

Spines are inserted into tubes and tubes are filled with lead.

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Battery Alloy Comparison

Calcium	**Plus**	**Great float battery, with little maintenance and upkeep.**
	Neg.	**Only 50 deep cycles in its life. Not high temperature tolerant.**
Antimony	**Plus**	**Cycles better then Calcium with 300 and handles heat better then Calcium**
	Neg.	**Requires one extra watering per year. About 3 times per yr.**
Tubular	**Plus**	**High cycling battery with 1200 cycles, and handles heat better than Calcium and Antimony.**
	Neg.	**2x cost and poor short duration rates**
Planté	**Plus**	**600 cycles and handles heat better then all others lead batteries. Very low watering maintenance required.**
	Neg.	**3x cost and poor short duration capacity.**

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Battery Alloy Comparison Cont.

BENEFIT	VRLA (FLOODED) PLATE ALLOY				VRLA
	CALCIUM	ANTIMONY	TUBULAR	PLANT'E	
LOW COST	BEST	GOOD	POOR	WORST	OK
LOW MANTENANCE	OK	WORST	POOR	GOOD	BEST
LOW WATERING	OK	WORST	POOR	GOOD	BEST
LOW GASSING	OK	WORST	POOR	GOOD	BEST
HIGH HEAT TOLERANT	POOR	OK	GOOD	BEST	WORST
LIFE LOSS AT 107F	75%	70%	65%	56%	80%
HANDLES HIGH # of CYCLES	WORST	POOR	BEST	GOOD	OK
CYCLES	50	300	1200	600	400
HIGH SHORT DURATION RATES	BEST	GOOD	WORST	POOR	OK
15 min rate as % of AH RATE	112%	109%	73%	94%	106.0%

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Battery Alloy Comparison Cont.

Characteristics	Types			
	Calcium Flat Plate	Low Antimony/Selenium Flat Plate	Planté	Tubular
Construction				
Positive Plate	Pasted Plate	Pasted Plate	Pure Lead Plate	Spine
Negative Plate	Pasted Plate	Pasted Plate	Pasted Plate	Pasted Plate
Specific Gravity				
Low/Tropical	1.210	1.210	1.210	1.210
Standard	1.215	1.215	1.215	1.215
Med/High	1.250	1.250	-	-

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Battery Alloy Comparison Cont.

Characteristics	Types			
	Calcium Flat Plate	Low Antimony/Selenium Flat Plate	Planté	Tubular
Watering Frequency	Low	Medium/high	Very Low	Medium
Typical Float voltage	2.17	2.15	2.17	2.17
Recharge voltage	2.25	2.20	2.20	2.20
Approx. cycles at 80% depth of discharge	50	300	600	1200

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Battery Alloy Comparison Cont.

Characteristics	Types			
	Calcium Flat Plate	Low Antimony/Selenium Flat Plate	Planté	Tubular
Float Life (years) at 47F (8C)	25	25	35	30
Float Life (years) at 77F (25C)	20	20	25	22
Float Life (years) at 107F(42C)	5	6	10-12	8
Energy Density				
Wh/kg	20-28	20-28	11	
Ah/kg	10-15	10-15	6	

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Battery Alloy Comparison Cont.

Characteristics	Types			
	Calcium Flat Plate	Low Antimony/Selenium Flat Plate	Planté	Tubular
Optimized for:	High performance	High cycling		High cycling
	Low maintenance			
Typical Applications	Telecom	Switchgear	Power Generation	Cycling (not UPS)
	UPS	Utility	Industrial	Solar
	Switch gear	Telecom	(not UPS)	

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Plate Type Summary.

	Planté	Flat	Tubular	Round
Grid	Pure Lead	Lead Alloy	Lead Alloy	Pure Lead
Life	Long	Medium	Long	V Long
Maintenance	Low	High	High	Low
Energy /density	High	High	Medium	Low
Cycling	Good	Poor - High	High	Poor
High Temp.	Good	Average	Good	Average
Initial Cost	High	Low	High	High

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Grid Material Summary.

	Pure Lead	Lead Selenium	Lead Calcium	Lead Antimony
Life	Long	Long	Low - Medium	Medium
Maintenance	Low	Low	Low	High
Cycling	Very Good	Very Good	Poor	Good
Temperature	Medium	Good	Poor	Poor
Comments	Used mainly in Europe	Used mainly in Europe	Used mainly in USA	Used in USA but declining

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Battery Plate Considerations.

Flat plate construction can be further optimized for different applications by plate thickness

Thicker plates perform better in long duration discharge applications, e.g. Telecom.

Thinner plates perform better in short duration discharge applications, e.g. UPS.

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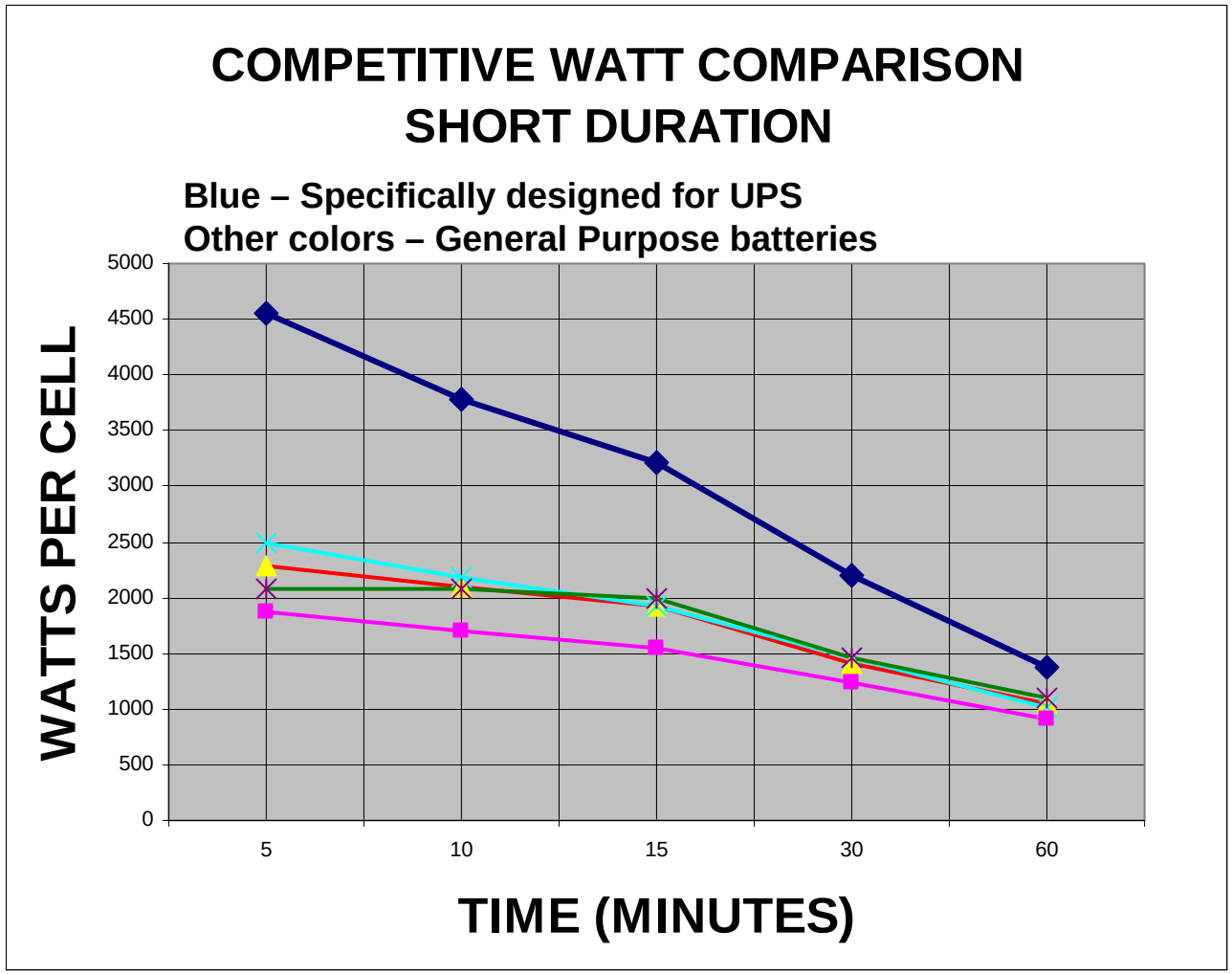

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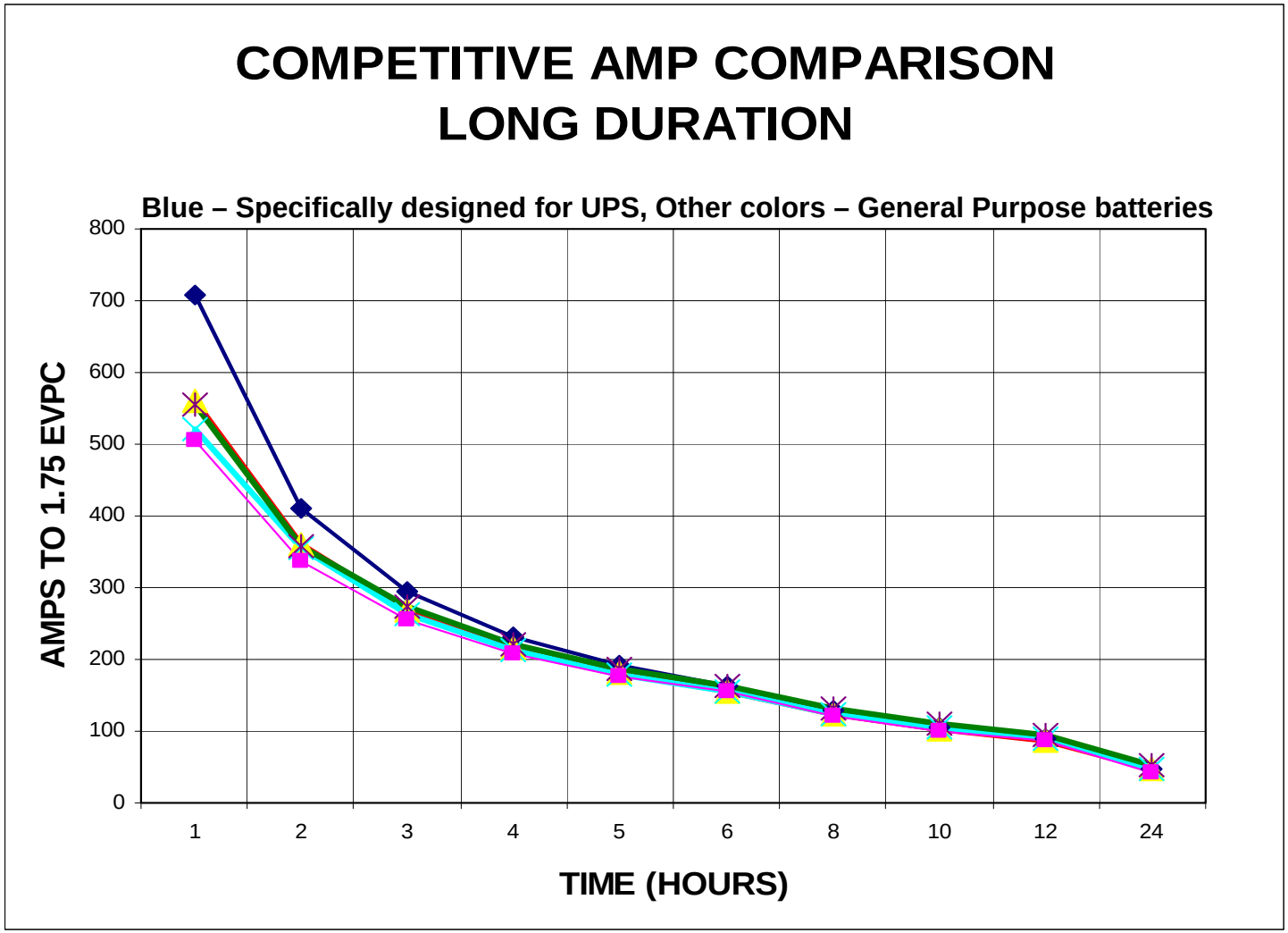

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Types of Pasted Plate Battery Cells.

Battery types discusses above are primarily Vented Lead-Acid (VLA) also called Flooded or Wet Cells.

When the electrolyte within a cell is immobilized it creates a Valve-Regulated Lead-Acid (VRLA) cell. There are two types:

- **Absorbed Glass Mat**
- **Gelled Electrolyte**

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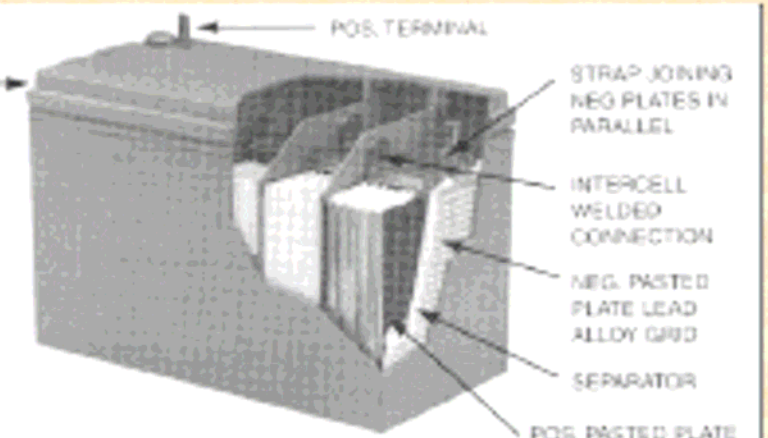
Valve-Regulated Construction



AGM VRLA Battery Construction

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Which Battery is Best?

Float Charge, long duration reserve, with infrequent discharge such as Telecom:

VLA

Flat Plate Lead Calcium	Good
Flat Plate Lead Selenium	Good
Planté	Good
Round Cell	Best

VRLA

Gelled Electrolyte	Good
Absorbed Class Mat	Better

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Which Battery is Best?

Short duration, high rate discharge such as UPS.

Batteries designed for general purpose or low rate discharge are really not suitable for UPS applications.

UPS batteries need to be able to deliver a lot of current over a relatively short period of time.

Very specific cell design criteria should be considered such as:

- **Thin-Plate (high surface area) design to allow for high rate discharge.**
- **Thick internal plate bus bar and large, heavy duty, cell posts to handle high currents.**
- **Low internal resistance. High Current carrying connectors.**

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Which Battery is Best?

Large UPS

VLA	Pasted Flat Plate.
VRLA	Lead Calcium with added alloys.

Medium UPS

VRLA	Lead Calcium with added alloys.

Small UPS

VRLA	Lead Calcium with added alloys.

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Which Battery is Best?

Deep and Regular Cycling Such as Switchgear: VLA

Flat Plate Lead Selenium	**Good**
Planté	**Better**
Tubular	**Best.**

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Which Battery is Best?

Broadband (Indoor)

- **Non cycling and climate controlled.**
  - **VRLA Absorbed Glass Mat**

Broadband (outdoor)

- **Non Cycling and not climate controlled**
  - **VRLA Gelled Electrolyte**

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Which Battery is Best?

Energy Storage

- Photovoltaic Deep cycle lead-acid
- Load Leveling
- Ride-through

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Battery Migration.

- 1970's Computing. Out of Large Mainframes into Networks.
- 1980's Telecom. Out of Central Office into Networks.
- 1990's IT. Out of Battery Room into Data Centers.

- The 10 Year, 90 Percent Postulation.
- 1976 90% of Stationary batteries in control of Telco's
- 1986 90% VLA. 10% VRLA
- 1996 90% VRLA. 10% VLA
- 2006 90% Batteries. 10% Other Technologies
- 2016 90% Other Technologies. 10% Batteries

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Key Points

- **The battery is going to fail, the objective should be to make that later rather than sooner.**
- **Battery Selection is important.**
- **Application has to be taken into consideration.**
- **Particular attention needs to be paid to operating conditions.**
- **A meaningful maintenance program must be put in place.**
- **Testing is important**

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Battery Management

Key is Ventilation and Maintainability

Avoid battery cabinets where possible

- **Ventilation is difficult**
- **Maintenance is seriously restricted.**

Monitoring is good.

Proper interpretation of the results is very important.

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Battery Fires Do Happen

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Thermal Run Away Does happen

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Batteries can cause explosions

Thank you

Questions???

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