

# VRLA BATTERY OPERATION & SELECTION FOR UPS APPLICATIONS

# INTRODUCTION

## A Battery With Many Names

- Sealed
- Maintenance Free
- Absorbed Electrolyte
- Starved

Valve Regulated Lead Acid Battery  
Or  
VRLA Battery

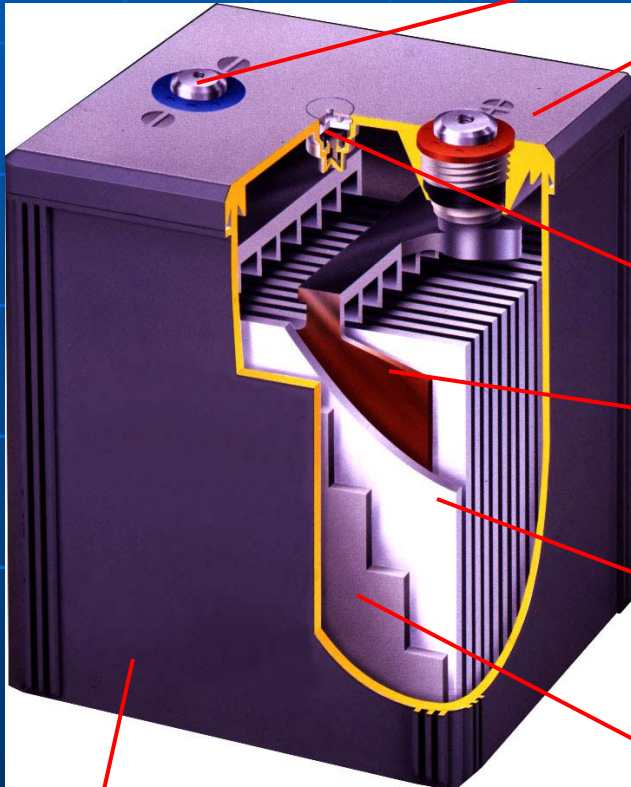
# TOPICS

- Battery Operation
- Safety
- Environmental Considerations
- Sizing
- Series and Parallel Operation

# BATTERY OPERATION

## Attributes Of A VRLA Battery

- Filling is not required
- Useable laying on sides or vertical
- Low self discharge (long shelf life)
- Short, high rate discharges
- Low cost
- Complexity & cost of associated electronics is low



Pillar/Top Lead

Safety valve

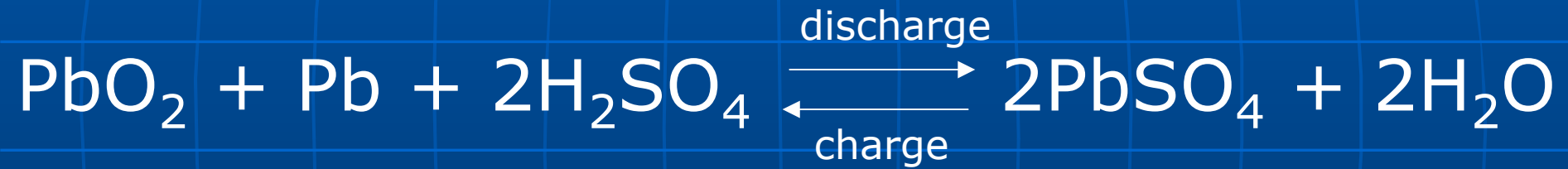
Positive pasted plate

AGM separator and electrolyte

Negative pasted plate

Container

# Positive and Negative Electrode Reactions



# Self Discharge Reactions

Negative



Positive





# Internal Oxygen Cycle (Oxygen Recombination)

Positive

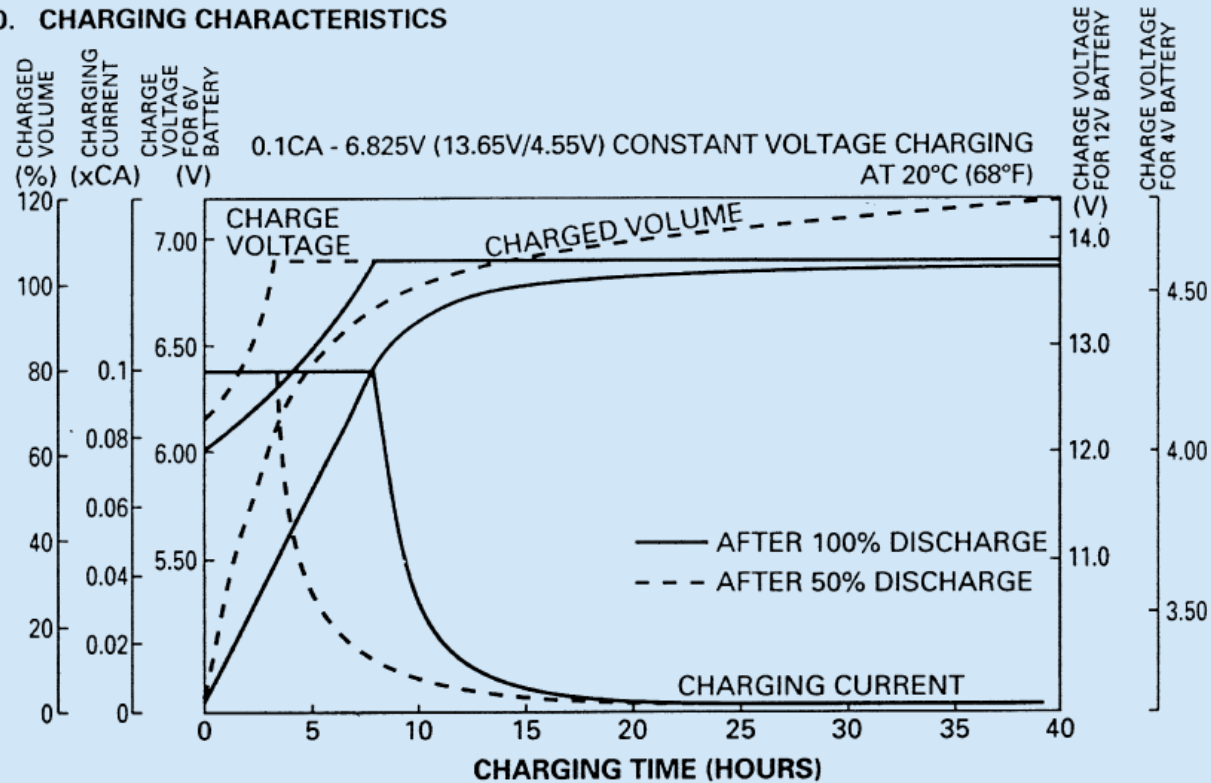


Negative



# CHARGING A VRLA BATTERY

Figure 10. CHARGING CHARACTERISTICS

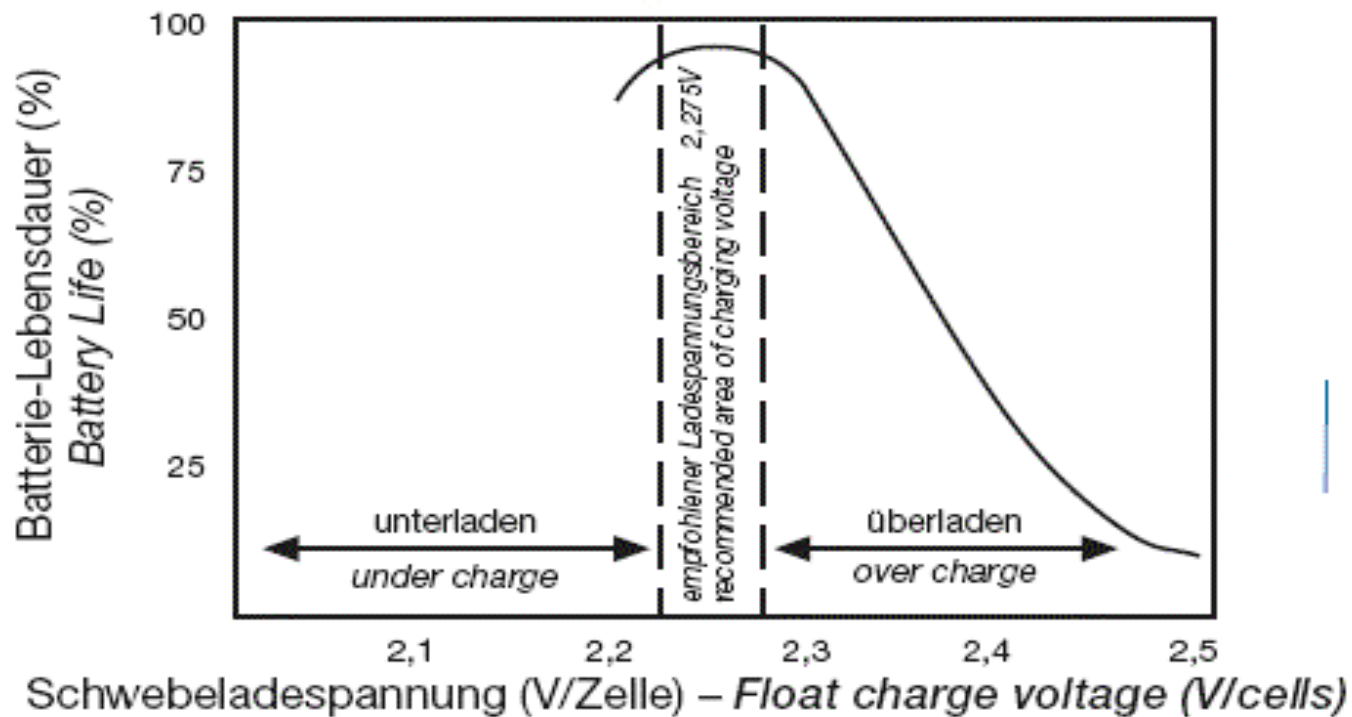


# CHARGE PARAMETERS

Float Voltage Range: 2.25 – 2.30 V/cell

Current Limit: 0.1C Amps  
(recommended minimum)

## Gebrauchsdauer in Abhängigkeit der Schwebeladespannungsvariabilität *Float Charge/Battery Life*



# Effect Of Current On Charge Time

Figure 10. CHARGING CHARACTERISTICS

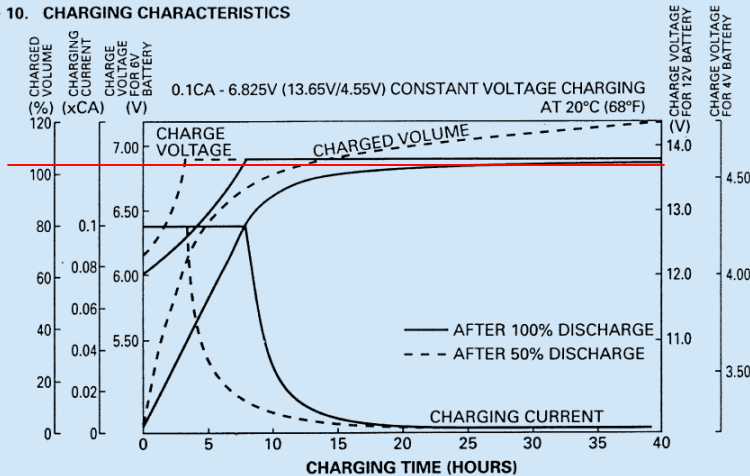
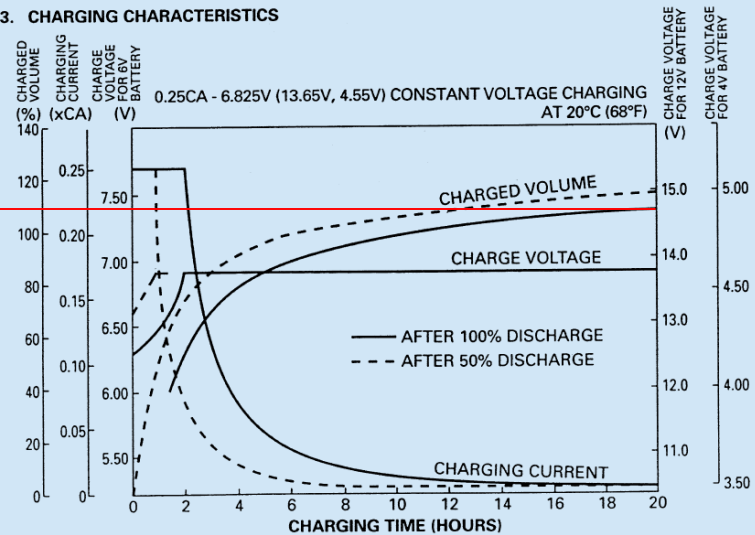


Figure 13. CHARGING CHARACTERISTICS



# FLOAT SERVICE LIFE

Definition: Length of time a battery can be on float charge until the capacity degrades to a specified value.

# FLOAT SERVICE LIFE PARAMETERS

- Rated or actual capacity
- Capacity at end of life (50%, 80%,...)
- Discharge rate (20 hr, 10 hr, 15 min)
- Discharge load (constant current or constant power)

# Float Service Life Specifications (from manufacturer's data sheets)

3 – 5 Years

5 – 7 Years

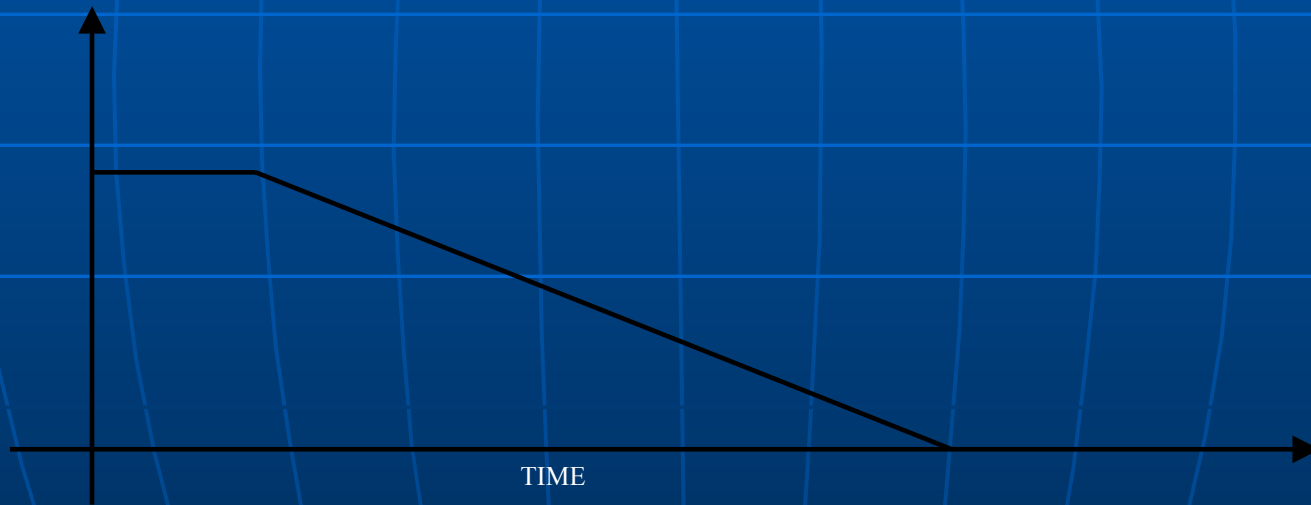
7 Years

10 Years



# Phases Of Float Service Life

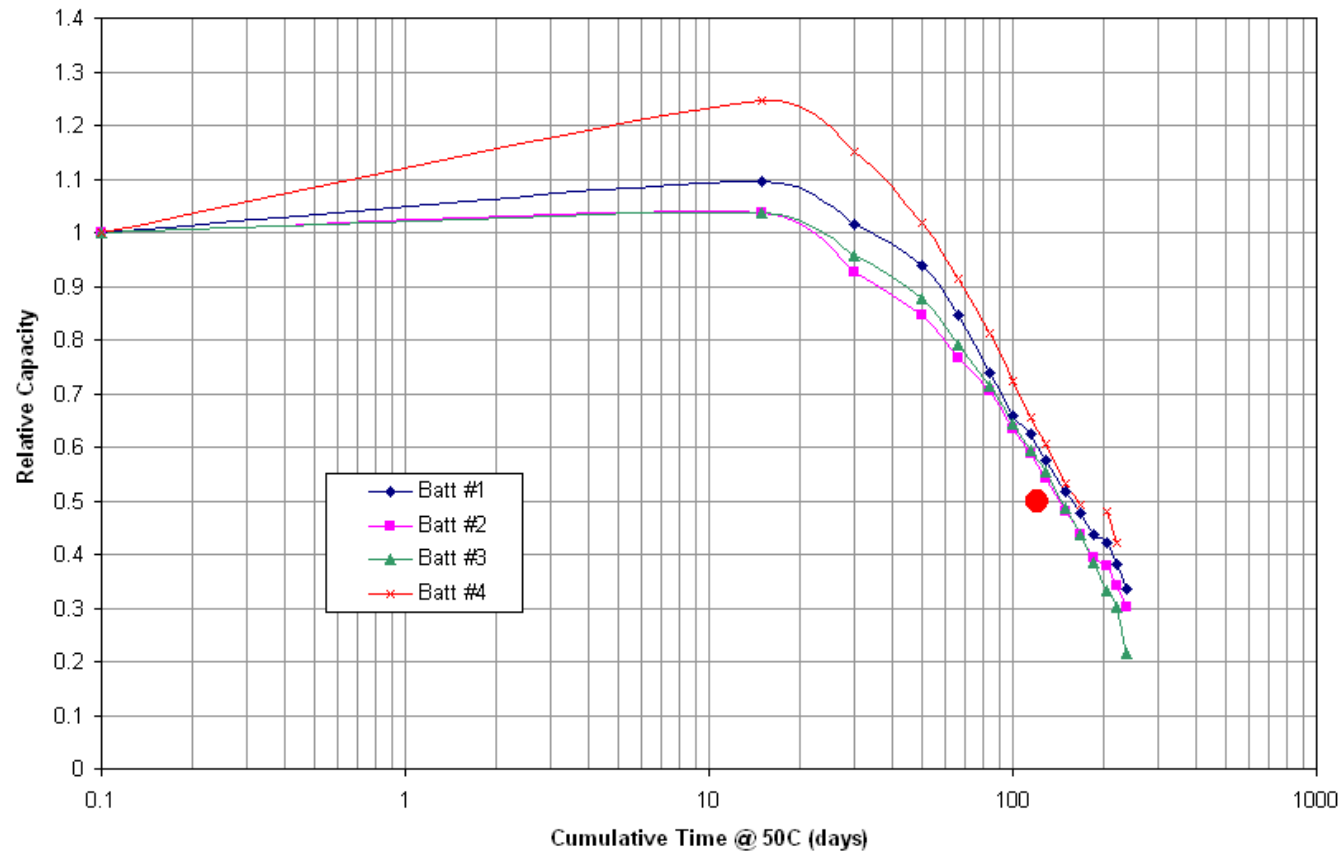
RELATIVE  
CAPACITY



# Mechanisms Which Govern Float Service Life

- Grid Corrosion
- Loss of Electrolyte

# Float Service Life Test



# Float Service Life Specification Summary

Test Temperature - 50°C

Float Voltage – 13.8 V

Discharge Interval – 15 Days

Discharge Type – CC, 17 A

End Voltage – 9.6 V

Float Service Life – 120 Days To 50% Of Initial  
Capacity

# SAFETY

## Safety & Regulatory Agencies

- UL – UL924 requires battery to meet pressure release test specified for standby batteries in UL1989
- U.S. DOT, IATA, IMDG – governs packing & transportation of VRLA batteries

## Safety & Regulatory Agencies, Cont.


- NFPA –
  - VRLA battery can be used in offices
  - No spill containment required
- International Fire Code (Section 608)
  - VRLA Battery Systems with >50 gallons of electrolyte must comply

# International Fire Code – Electrolyte Volume

Document from C&D Dynasty that lists  
the electrolyte volume by model  
number

<http://www.cdtechno.com/custserv/pdf/hazmat.pdf>

# Example from document



Product Line	Model	# of Cells per unit	Specific Gravity	Lead Weight per Cell (Lbs)	Electrolyte Weight per Cell (Lbs)	Pure Sulfuric Acid Weight per Cell (Lbs)	Electrolyte Volume per Cell (Gal)
UPS High Rate	UPS12-370 / FR	6	1.300	9.2	2.3	0.9	0.2
UPS High Rate	UPS6-620 / FR	3	1.300	17.0	4.5	1.8	0.4
UPS High Rate	UPS12-475 / FR	6	1.300	12.4	3.2	1.3	0.3
UPS High Rate	UPS12-530 / FR	6	1.300	12.7	3.2	1.3	0.3
UPS Max Rate	MR12-150	6	1.300	3.5	0.7	0.3	0.1
UPS Max Rate	MR12-210	6	1.300	5.0	1.2	0.5	0.1
UPS Max Rate	MR12-300	6	1.300	7.1	1.8	0.7	0.2
UPS Max Rate	MR12-350	6	1.300	8.2	2.1	0.8	0.2
UPS Max Rate	MR12-400	6	1.300	9.2	2.3	0.9	0.2
UPS Max Rate	MR12-490	6	1.300	12.4	3.2	1.3	0.3
UPS Max Rate	MR12-540	6	1.300	12.7	3.2	1.3	0.3
UPS High Rate Max	UPS12-100MR	6	1.300	2.6	0.7	0.3	0.1
UPS High Rate Max	UPS12-150MR	6	1.300	3.5	0.7	0.3	0.1
UPS High Rate Max	UPS12-210MR	6	1.300	5.0	1.2	0.5	0.1
UPS High Rate Max	UPS12-300MR	6	1.300	7.1	1.8	0.7	0.2
UPS High Rate Max	UPS12-350MR	6	1.300	8.2	2.1	0.8	0.2
UPS High Rate Max	UPS12-400MR	6	1.300	9.2	2.3	0.9	0.2
UPS High Rate Max	UPS12-490MR	6	1.300	12.4	3.2	1.3	0.3
UPS High Rate Max	UPS12-540MR	6	1.300	12.7	3.2	1.3	0.3
UPS High Rate Max	UPS6-620MR	3	1.300	17.0	4.5	1.8	0.4



# Material Safety Data Sheet (MSDS)

A VRLA battery is classified as an "article".

An article is a manufactured item:

- i) which is formed to a specific shape or design during manufacture
- ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use
- iii) which does not release, or otherwise result in exposure to a hazardous chemical under normal conditions of use

## Material Safety Data Sheet, Cont.

Conclusion – An MSDS is not required for a VRLA battery

# Gassing & Room Ventilation

Building requirements restrict hydrogen ( $H_2$ ) gas generation to 1% - 2% of room volume

Document from C&D Dynasty provides gassing data and the method for calculating air exchange required

<http://www.cdtechno.com/custserv/pdf/6739.pdf>

# Environmental Considerations

Only one important fact to remember....

If the environment is uncomfortable to a human, it is bad for a VRLA battery

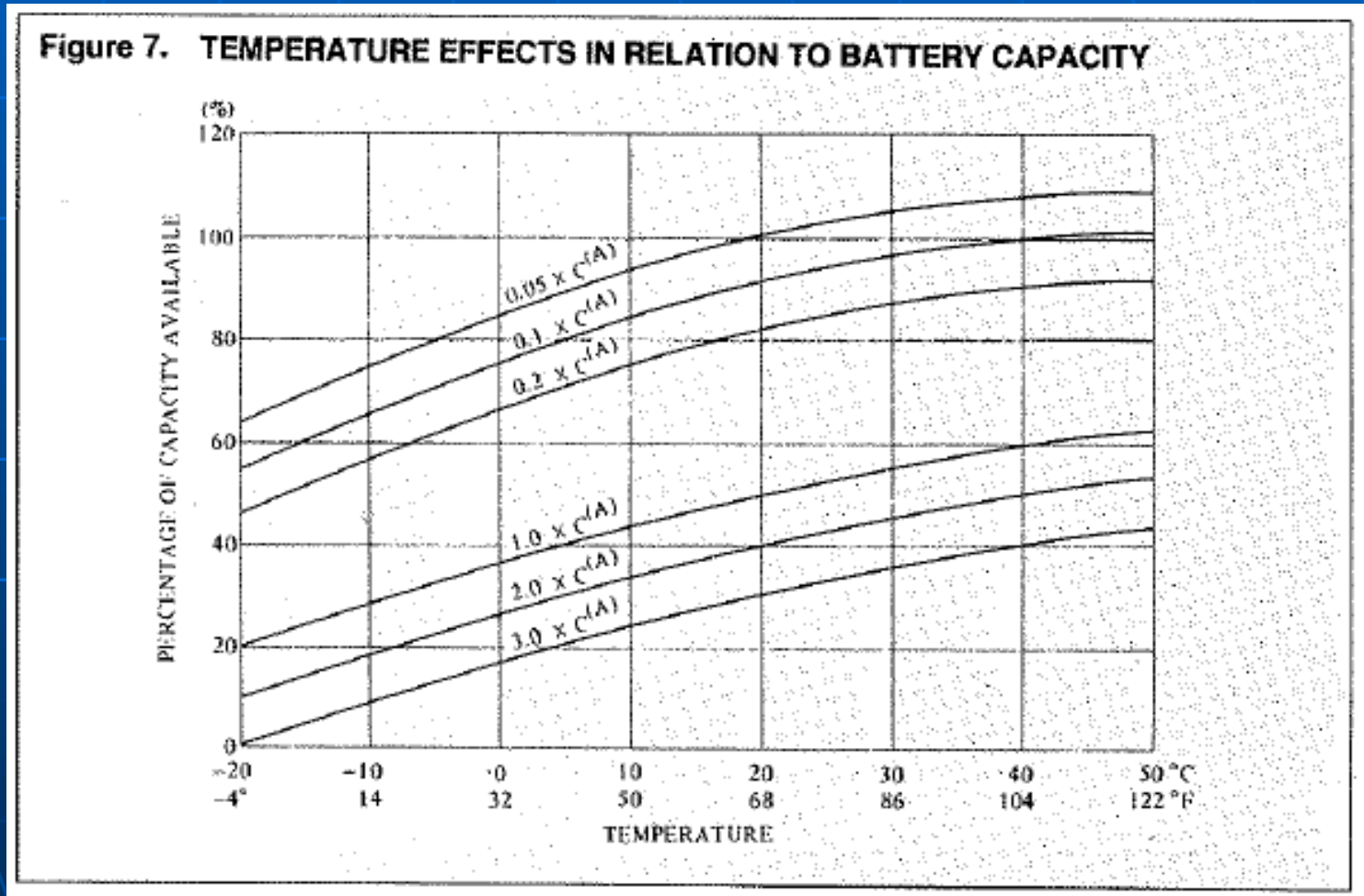
## Higher Temperature

- Discharge time increases
- Float service life decreases
- Shelf life decreases

## Lower Temperature

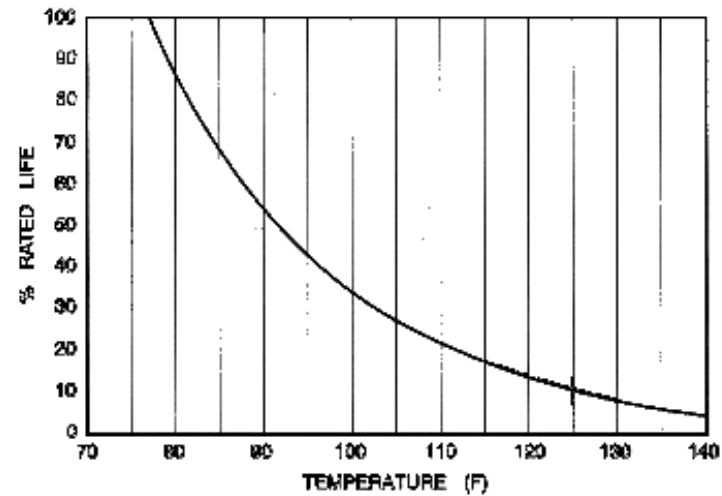
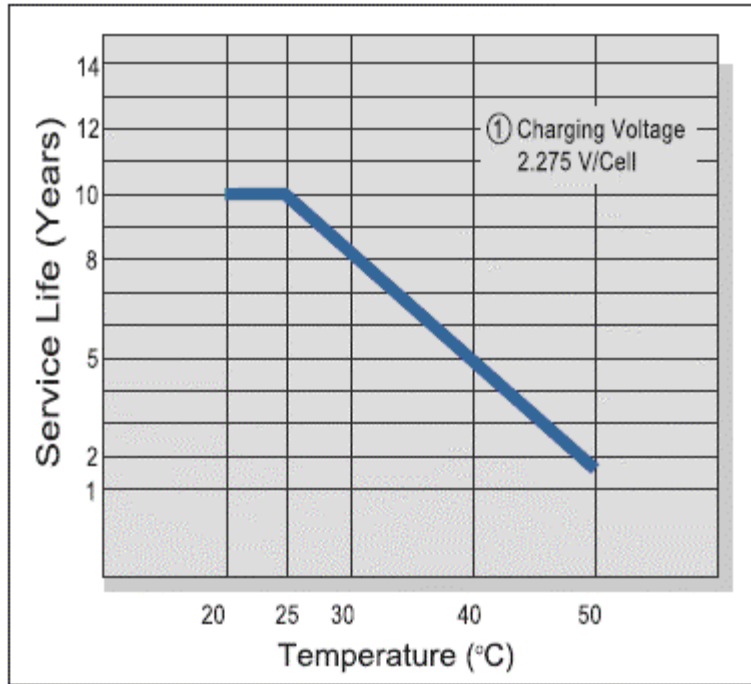
- Discharge time decreases
- Float service life increases
- Shelf life increases

# Temperature vs. Capacity



# Temperature vs. Float Service Life

## Trickle (or Float) Service Life



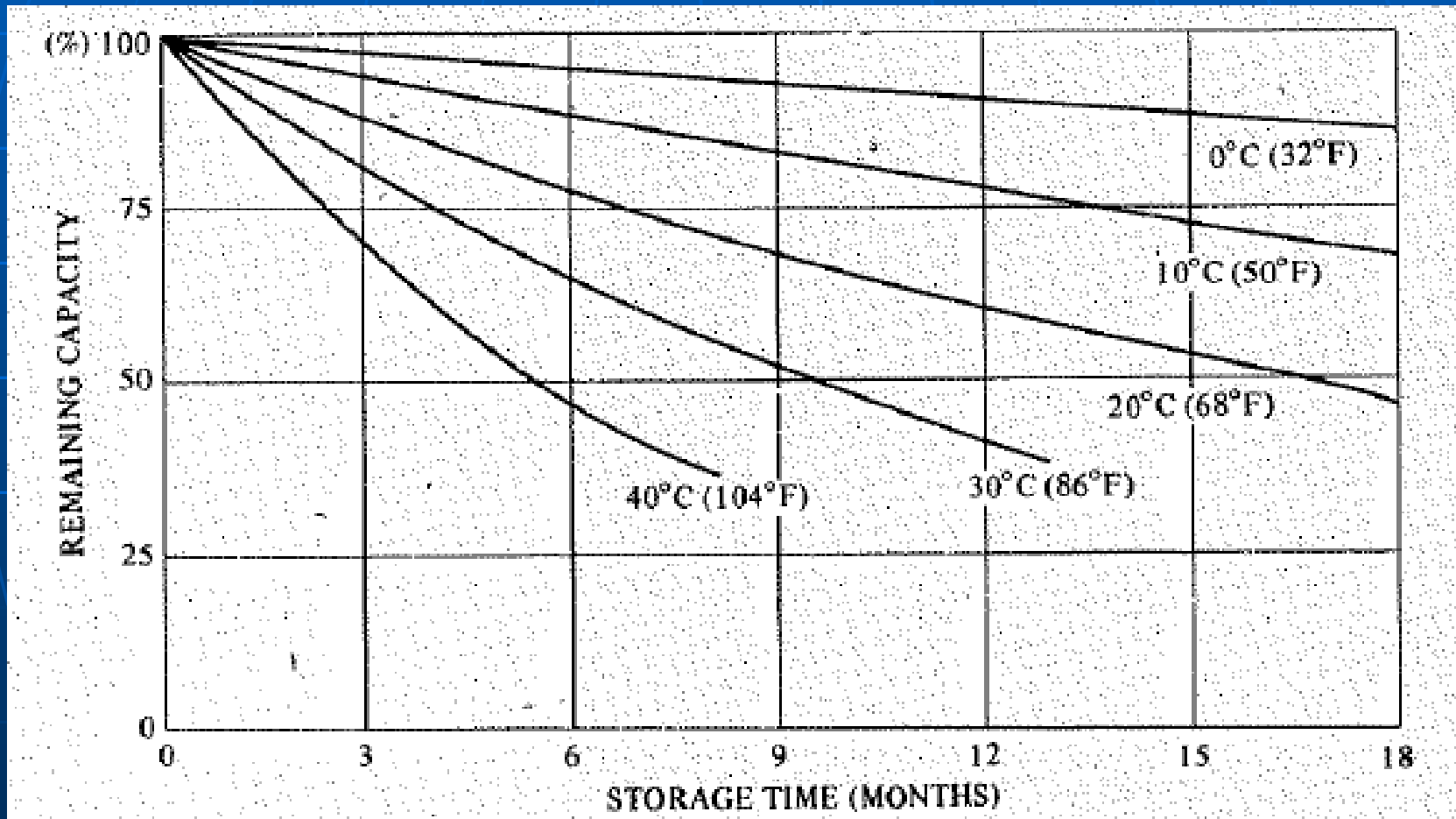
Lead Acid Battery % Life (D-γ) VS. Temperature



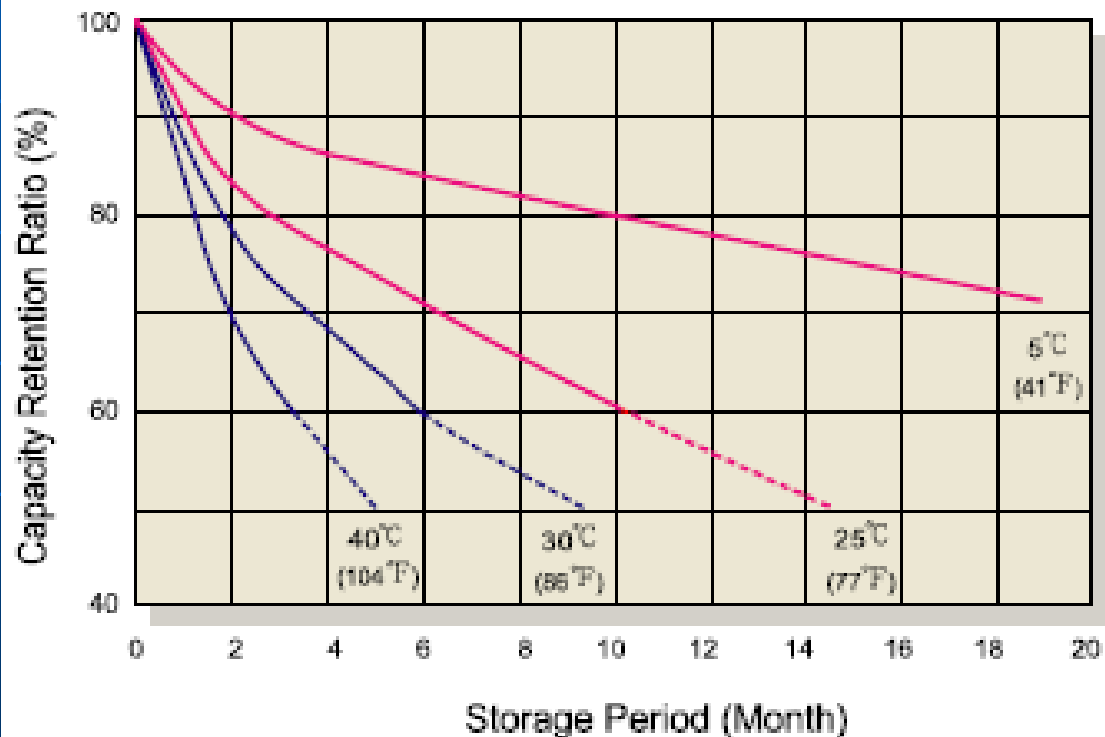
## Shelf Life

- Defined as the length of time a battery can sit, open circuited, and still be recharged to 100% capacity with only one charge.
- Shelf life is determined by the time until the battery loses 40%-50% of its' capacity.

# Shelf Life, Cont.



# Shelf Life, Cont.



- No supplementary charge required (Carry out supplementary charge before use if 100% capacity is required)
  - Supplementary charge required before use. This supplementary charge will help to recover the capacity and should be made as early as possible.
  - Supplementary charge may often fail to recover the capacity. The battery should never be left standing till this state is reached.
- Supplementary charge and storage guidelines

# Battery Sizing

## Information Needed

- UPS Load (either Watts or power factor if using VA)
- Efficiency of the UPS operating from battery and cutoff voltage
- Expected discharge time
- Number of batteries in series

## Battery Sizing, Cont.

### UPS Load (Watts)

$$UPSLoad(Watts) = pf \times UPSLoad(VA)$$

### Battery Load (Watts)

$$P_b = \frac{UPSLoad(Watts)}{efficiency}$$

### Individual Battery Load (Watts/battery)

$$P_1 = \frac{P_B}{stringsize}$$

# Battery Sizing, Cont.

Constant Power Discharge Characteristics Unit:Watt(25°C,77°F)

F.V/Time	5MIN	10MIN	15MIN	20MIN	30MIN	40MIN	45MIN	50MIN	60MIN	90MIN
1.60V	3,354	2,304	1,788	1,476	1,110	888	822	762	648	485
1.67V	3,036	2,166	1,700	1,417	1,079	876	804	738	636	466
1.70V	2,880	2,100	1,643	1,384	1,060	864	792	726	618	454
1.75V	2,615	1,955	1,575	1,326	1,023	834	780	703	600	436
1.80V	2,329	1,800	1,493	1,274	980	802	738	678	581	422
1.85V	2,016	1,656	1,408	1,212	938	760	694	636	550	404

● All mentioned values are average values.

## Example

UPS Load: 136.5 kVA

Power Factor: 0.8

UPS Efficiency On Battery: 91%

String Size: 40 Batteries

End Voltage: 400.8 V, 1.67 V/cell

Expected Discharge Time: 15 minutes

UPS Load In Watts: pf x UPS Load in VA

$$0.8 \times 136.5 \text{ kVA} = 109.2 \text{ kW}$$

Battery Load: UPS Load (W)/UPS Eff. On Batt.

$$109.2 \text{ kW}/0.91 = 120 \text{ kW}$$

or

Battery Load/Batteries In String

$$120 \text{ kW}/40 \text{ batteries} = 3000 \text{ W/battery}$$



# Battery Sizing, Cont.

## HRL12280

Constant Power Discharge Characteristics Unit:Watt(25°C,77°F)

F.V/Time	5MIN	10MIN	15MIN	20MIN	30MIN	40MIN	45MIN	50MIN	60MIN	90MIN
1.60V	3,354	2,304	1,788	1,476	1,110	888	822	762	648	485
1.67V	3,036	2,166	1,700	1,417	1,079	876	804	738	636	466
1.70V	2,880	2,100	1,643	1,384	1,060	864	792	726	618	454
1.75V	2,615	1,955	1,575	1,326	1,023	834	780	703	600	436
1.80V	2,329	1,800	1,493	1,274	980	802	738	678	581	422
1.85V	2,016	1,656	1,408	1,212	938	760	694	636	550	404

● All mentioned values are average values.

## HRL12500

Constant Power Discharge Characteristics Unit:Watt(25°C,77°F)

F.V/Time	5MIN	7.5MIN	10MIN	15MIN	20MIN	30MIN	40MIN	50MIN	60MIN	90MIN
1.60V	5,275	4,691	4,167	3,181	2,594	1,951	1,558	1,292	1,112	783
1.67V	4,880	4,300	3,790	3,018	2,490	1,871	1,520	1,276	1,091	769
1.70V	4,640	4,110	3,610	2,932	2,422	1,829	1,507	1,258	1,083	763
1.75V	4,250	3,750	3,290	2,748	2,309	1,740	1,466	1,237	1,066	754
1.80V	3,830	3,340	2,950	2,497	2,138	1,657	1,390	1,186	1,025	731
1.85V	3,366	2,882	2,600	2,203	1,964	1,564	1,321	1,130	977	695

● All mentioned values are average values.

# Maintaining A VRLA Battery

- Do not let the shelf life expire before recharging
- Install battery in a comfortable environment
- Pay particular attention to room ventilation and spacing from walls
- Charge the battery for 48 hours before performing a discharge

## Maintaining A VRLA Battery, Cont.

- Do not leave the battery in a discharged condition
- Charge the batteries at, but do not exceed, 2.30 V/cell