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BATTERIES

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Batteries

- Battery capacity – how much energy can a battery store?
- Measuring battery state of charge
- Types of batteries
- Battery lives – how long will a battery last?
- Sizing batteries
- Working safely with batteries
- Battery rooms

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Batteries - important points

- Batteries should never be discharged completely
  - 50% or less is recommended for a leisure battery
  - 80% or less is recommended for a deep-cycle battery
- The battery should be able to deliver the energy required in one cycle
  - in a solar system this is one day
- There should also be storage capacity for the days on which there is not enough sun or wind

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Battery capacity

- Batteries are sized in amp-hours [Ah]
  - A battery which can deliver 1 amp for 100 hours has a capacity of 1 x 100 amp-hours or 100Ah
  - A battery which can deliver 10 amp for 10 hours has a capacity of 10 x 10 amp-hours or 100Ah
- *However .....*

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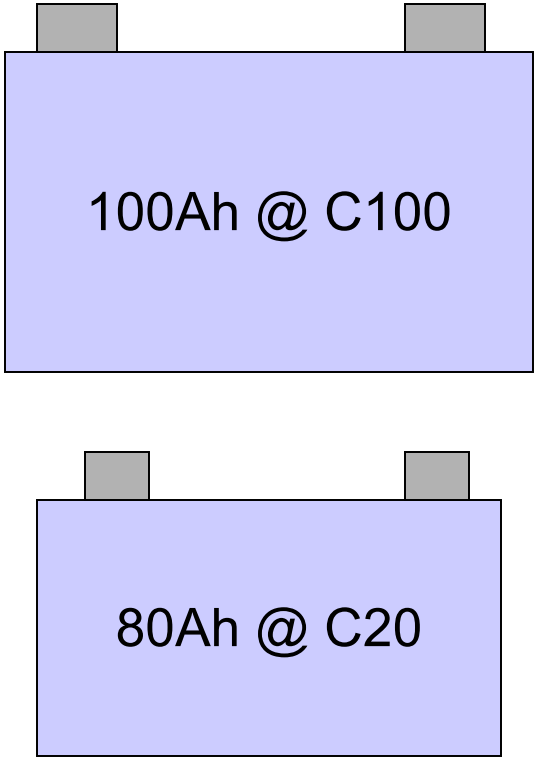
Battery C-rates

- The Ah capacity of a battery varies according to the rate at which it is discharged
- A battery discharged at a rate of 1 amp will have a higher Ah capacity than a battery discharged at a rate of 4 amps
- Example: a battery which can deliver 1 amp for **100 hours** has a capacity of 100Ah @ **C100**
- Example: the same battery may only deliver 4 amps for **20 hours**. Then its capacity is 80Ah @ **C20**
- C100 means discharged over 100 hours, C20 means discharged over 20 hours



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Batteries and watt-hours

Batteries are sized in amp-hours [Ah], however one can use watt-hours [Wh] for basic calculations

To calculate the watt-hour capacity of a battery:

$$\mathbf{Wh = Ah \times V_{system}}$$

Example: a 100 Ah 12 V battery = 1200 Wh

This method not very accurate but useful for for initial calculations

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Basic battery bank sizing method

The following calculation can be used (for small systems):

Daily energy requirement [Ah]

x number of days of storage required

÷ maximum depth of discharge [e.g. 0.5 for 50%]

Example: if 50 Ah are needed each day, 3 days storage are required and the battery is to be discharged by a maximum of 80%, then

50 Ah x 3 ÷ 0.8 = 188 Ah

188 Ah is the minimum required

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Maximum discharge currents

Batteries usually have specified maximum discharge currents

This is the maximum current that can be drawn from a battery at any one time

For a example, the recommended discharge current for a 100 Ah battery might be 10 A

In this case, the maximum load connected to the battery should be no greater than

12 V x 10 A = **120 W**

So, taking inefficiencies in account, the maximum size of inverter that should be connected to this battery is 100 W

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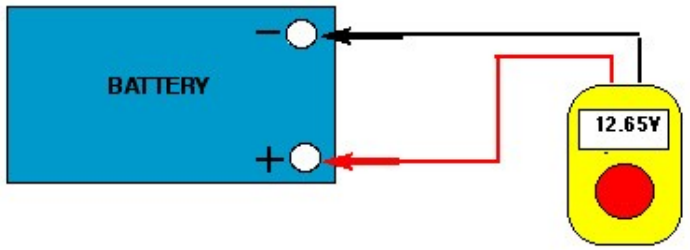
Measuring battery state of charge with a voltmeter

- This method is not very accurate but is safe and useful
- Any reasonably accurate digital voltmeter can be used
- Before this test is carried all power sources and loads should be disconnected
- Power sources, when charging increase battery voltage while loads and depress it. The batteries then needs about half an hour to settle
- As batteries age they also deteriorate. An old battery may give high voltage readings but in fact the state of charge is low. A near dead battery can give a high voltage reading even for an hour or so after being charged but this will drop considerably overnight
- This method can also be used to isolate defective batteries



VOLTS	SoC	VOLTS	SoC
12.74	100%	12.13	50%
12.62	90%	12.00	40%
12.50	80%	11.87	30%
12.36	70%	11.75	20%
12.25	60%		

Readings for a specific battery

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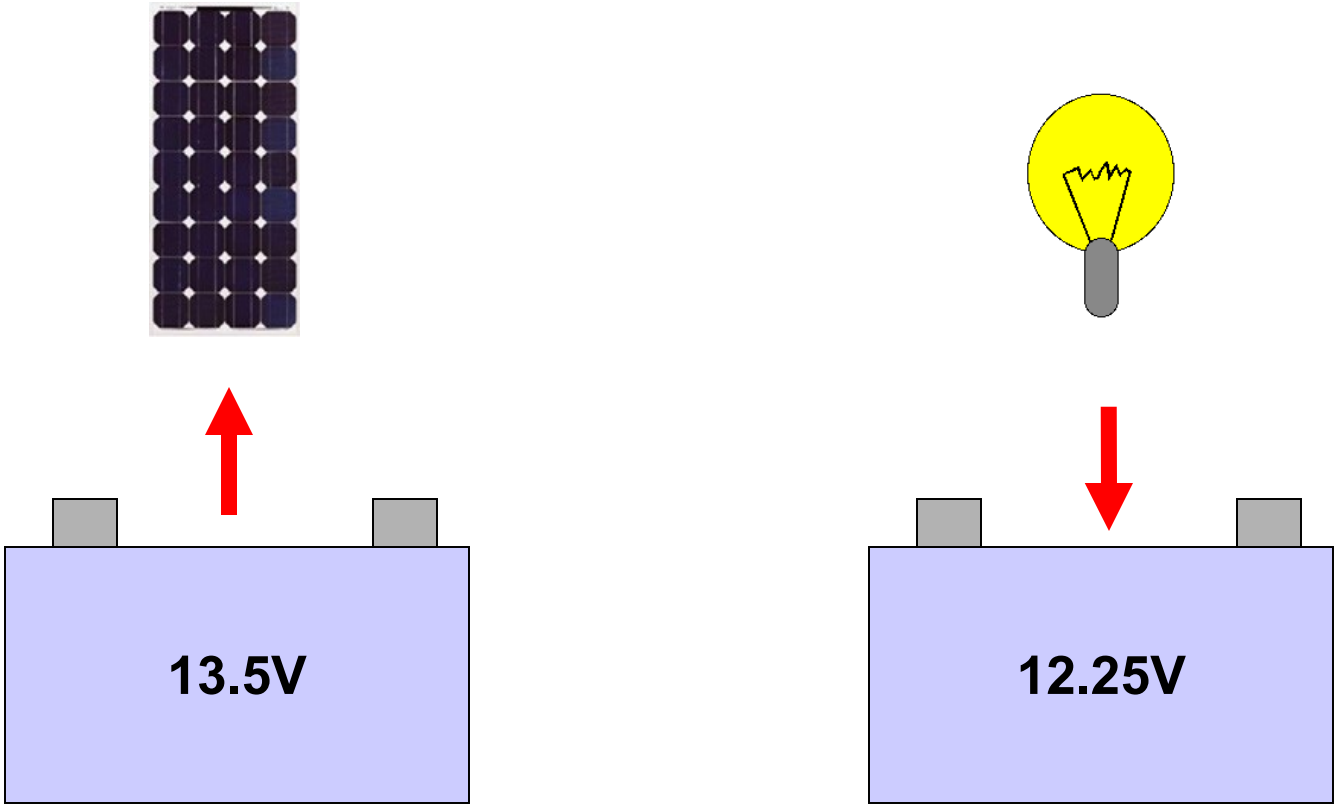
Battery voltage under charge & under load



Voltage rises under charge

Voltage falls under load

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Measuring battery SoC with an hydrometer

- An hydrometer is an accurate method of determining battery state of charge
- Electrolyte density is called its *specific gravity*
- Meaning of reading will depend on battery make but generally at 25º C
  - above 1250 is fully charged
  - 1200 - 1250 is half charged
  - 1150 - 1200 is low
  - below 1150 is dead
- Readings will be lower at higher temperatures

SAFETY

- Goggles and rubber gloves should be worn and hands washed afterwards
- A supply of water should always be at hand

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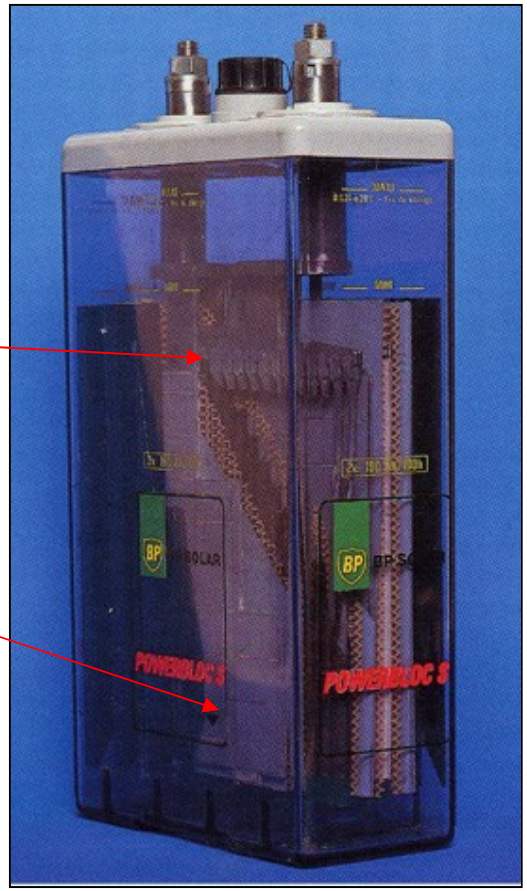
Stratification

- Sometimes the electrolyte will stratify, the lower density floating to the top of the cell - this is called stratification
- This will give *false* hydrometer readings

Lower density electrolyte

Higher density electrolyte



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Types of batteries - overview

Usual type description	Modified SLI	Gel cells, maintenance-free	Maintenance-free deep cycle	Flooded deep cycle
Construction	Thicker plates than SLI (automotive)	Maintenance-free, sealed	Gel electrolyte, tubular plates	Liquid electrolyte, tubular plates, transparent containers
Properties	Moderate to low water loss, low self-discharge rate	No maintenance	Low maintenance, can withstand deep discharge	Low maintenance, robust construction, charge well with low currents, can withstand deep discharge
Unit voltages	12 V	12 V	2 V – 6 V	2 V – 6 V
Capacity range in Ah	60 – 260 Ah	10 – 130 Ah	200 – 12,000 Ah	20 – 2,000 Ah
Self-discharge rate – monthly	2 – 4 %	3 – 4 %	< 3 %	2 – 4 %
% DOD – cycle life (approximate)	20 % – 1000 40 % – 500	30 % – 800 50 % – 300 (can be less)	30 % – 3000 80 % > 1000	30 % – 4500 80 % > 1200
Maintenance periods	3 months approx.	None	Monitoring & yearly cleaning	3 month approx.

From *Photovoltaics for Professionals*

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SLI Batteries

- Truck batteries ***not*** car batteries usually
- Far from ideal, but may be the only option – used in many small lighting systems in developing world
- Used in small solar home systems (lights / small TV)
- Cannot be deep-discharged
- Life: 2 years **max**.

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Small recreational batteries / Gel cells

- Sealed units
- Used in caravans, gardens sheds
- Expected life: 2-3 years
- Recommended DoD: 10-30%
- Maximum allowable DoD: 30-80%
- Maintenance: none
- Should not be overcharged

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Elecsol carbon fibre batteries

- Wet cell
- Reinforced carbon plates
- Up to 270Ah @ C20
- Expected life: 4 years
- Recommended DoD: 50%
- Maximum DoD: 80%
- Maintenance required
- www.elecsolbatteries.com

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Traction batteries

- Used in electric vehicles
- Up to 1500Ah
- Expected life: 4 years
- Recommended DoD: 40%
- Maximum allowable DoD: 80%
- Maintenance: electrolyte level needs to be checked weekly
- Self-discharge rate of 5-10% per month

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Stand-by batteries

- Used in stand-by applications in telecommunications
- Expected life: 3 - 10 years
- Recommended DoD: 20%
- Maximum DoD: 30-40%
- Maintenance: low electrolyte loss
- Not designed for deep discharge
- Available second-hand

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Tubular cell / deep-cycle batteries

- Description: specially developed for remote applications
- Tubular cells
- Expected life: 5-10 years
- Recommended DoD: 50%
- Maximum DoD: 80%
- Maintenance: electrolyte topping up once or twice a year

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Product features customer benefits

- Tubular plate
  = **long life in cyclic operation**
- DIN product of up-to-date design
  = **compatibility with existing installations**
- System terminal / system connector
  = **exclude corrosion**
  = **prevent short-circuits even during installation**
- AquaGen® recombinator (optional)
  = **extremely long intervals between topping-up with water, even total freedom from maintenance**

Main applications:

- **IT/Telecom**
- **Security lighting**
- **Solar**

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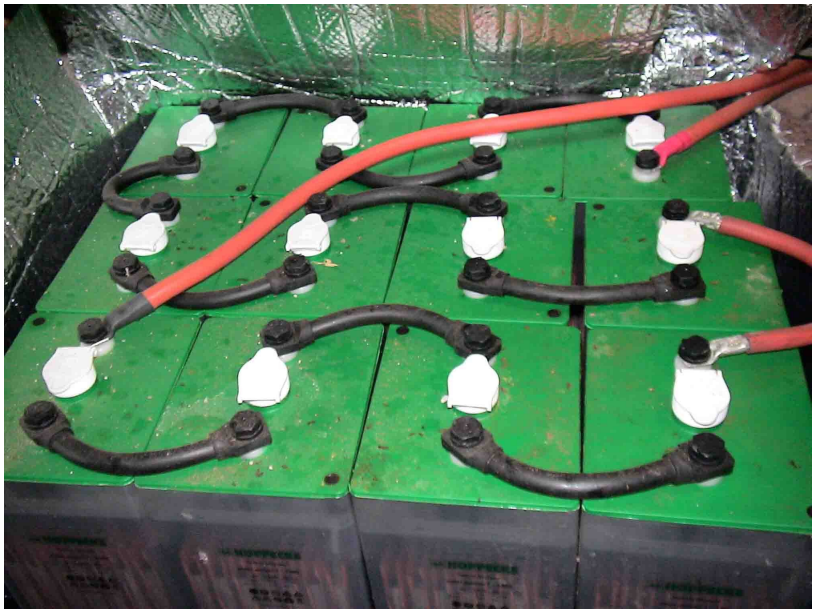
String of cells

- Individual cells are connected in strings to provide the required voltage
- 6 cells for 12V
- 12 cells for 24V



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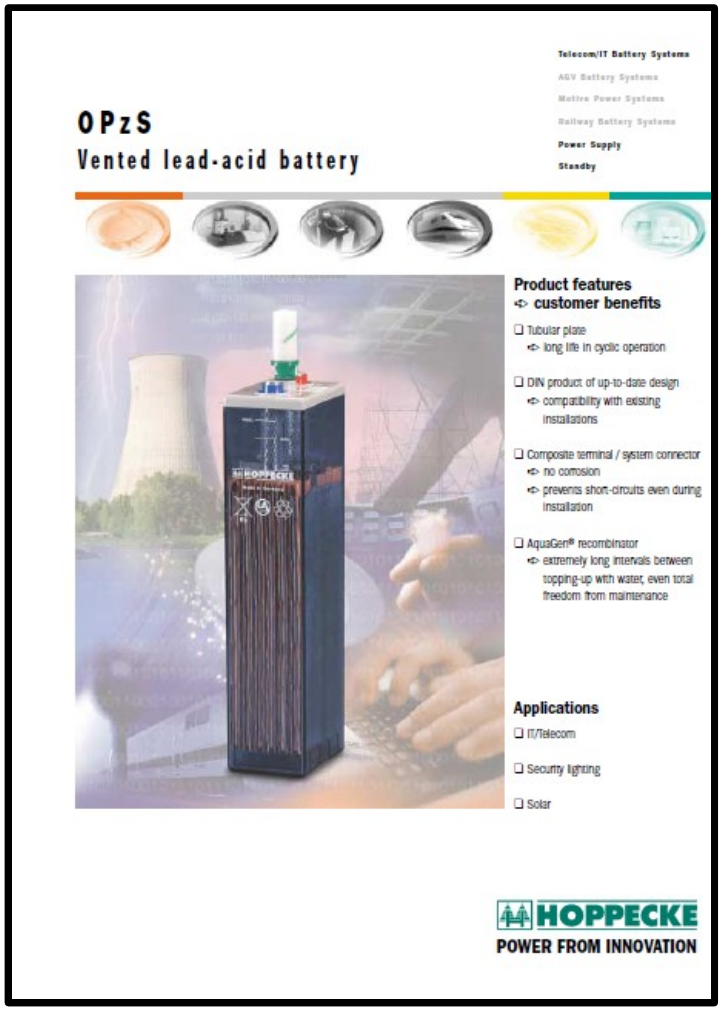
Battery specification sheets

- Battery specifications sheets will give information on
  - capacities
  - life cycles
  - operating temperatures



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OPzS Type Overview

HOPPECKE

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Capacities, Dimensions and Weights

Type	C_{10}/1.80 V Ah	C_5/1.77 V Ah	C_3/1.75 V Ah	C_1/1.67 V Ah	Weight kg	Weight of electrolyte (density 1.24 kg/l) kg	Length L mm	Width W mm	Height H mm
4 OPzS 200	200	174	150	107	17.2	4.9	208	105	420
5 OPzS 250	250	221	189	135	20.8	6.1	208	126	420
6 OPzS 300	300	262	225	161	24.3	7.2	208	147	420
5 OPzS 350	370	318	270	195	26.9	7.9	208	126	535
6 OPzS 420	450	385	324	234	31.5	9.4	208	147	535
7 OPzS 490	520	446	378	273	36.1	10.9	208	168	535
6 OPzS 600	610	523	453	324	44.8	12.9	208	147	710
8 OPzS 800	810	698	603	432	61.3	16.9	215	193	710
10 OPzS 1000	1010	872	753	541	74.6	21.1	215	235	710
12 OPzS 1200	1210	1047	903	649	88.0	25.5	215	277	710
12 OPzS 1500	1530	1313	1146	796	114.3	34.2	215	277	855
16 OPzS 2000	2030	1749	1527	1061	151.5	48.0	215	400	815
20 OPzS 2500	2540	2185	1908	1326	193.0	68.0	215	490	815
24 OPzS 3000	3050	2621	2289	1591	246.0	76.0	215	580	815

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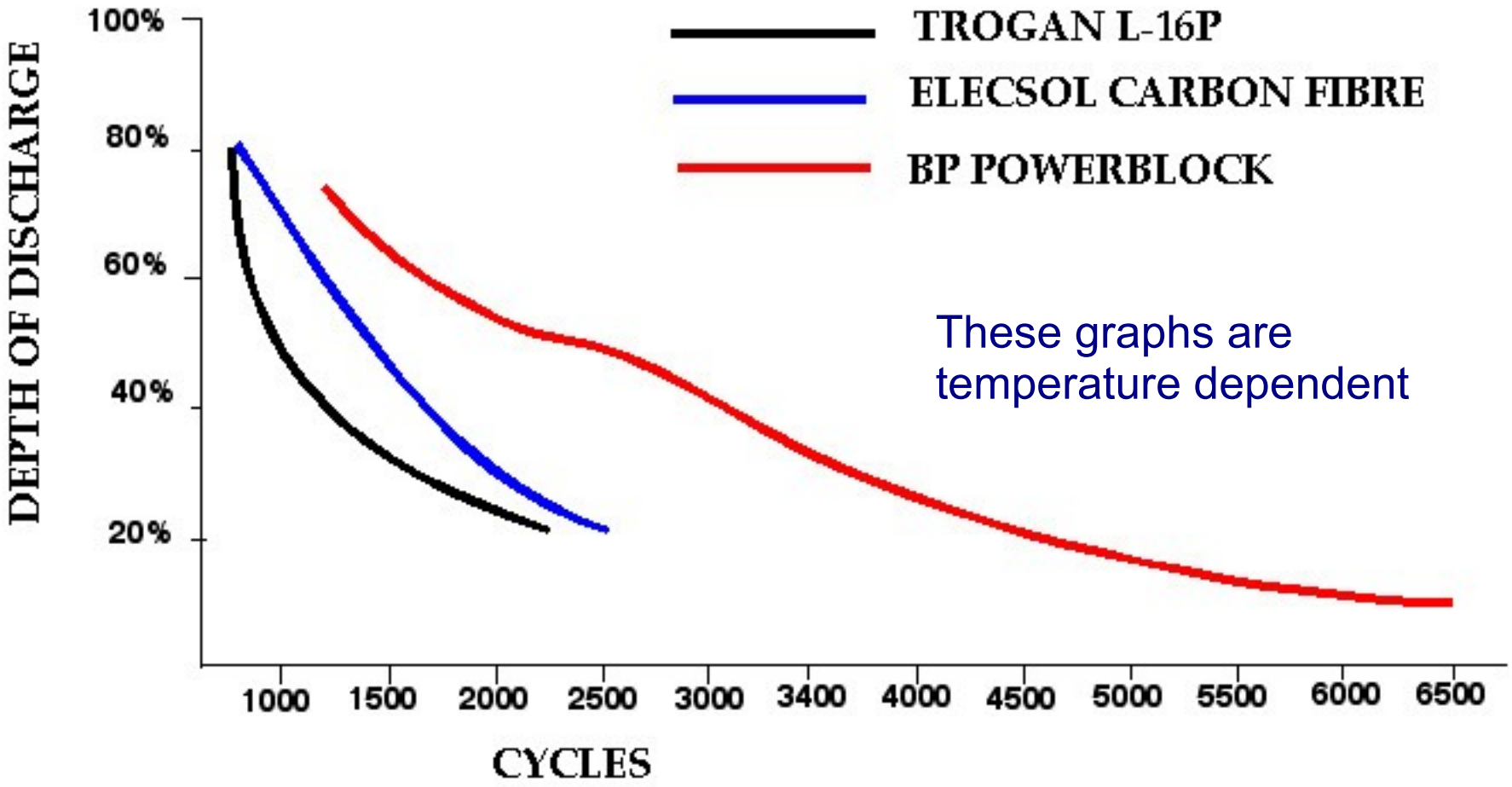
Batteries cycle life



These graphs are temperature dependent

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Battery cycle life and temperature

- Cycle life graphs / tables are usually given for a battery temperature of 20º C
- At higher temperatures the battery life will be shorter.
- An increase of temperature from 20º C to 30º C can reduce battery life by half
- Battery specification sheets and manuals need to be checked
- Battery suppliers should be consulted

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Battery safety issues

- Batteries emit explosive hydrogen gas
- Battery short circuits release very large currents which can cause explosions and fire
- Terminals should have protective colour coded caps
- Flame retardant cell caps
- Battery acid is corrosive and can cause blindness
- Batteries contain toxic materials, they need to be disposed of correctly/recycled

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Battery boxes

- Batteries should be in boxes
- Boxes should have covers
- Boxes should be ventilated
- Boxes should be locked to prevent access by children etc.
- Can be made locally
- Larger systems (more than 2 batteries) need battery room

Painting locally made wooden battery boxes for Wasso Hospital, Tanzania

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Battery rooms and boxes

Large battery banks are installed in a locked ventilated room

Separate rooms for batteries & inverters/switchgear etc. if the batteries are not sealed.

Comply with regulations!

Access for authorised persons only

One or two batteries can be lodged in special boxes

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Battery stands / racks


Sollatek
solar systems
خطر الموت
Danger of death

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Temperature

- Battery temperature sensors
  - From inverter-charger
  - From charge controller
- The lower the temperature the higher the voltage required to charge a battery effectively
- Electrolyte must not be allowed to freeze

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Battery equalisation charge

- Some flooded cells batteries, especially deep cycle cells require a periodic equalisation charge
- During equalisation the batteries are overcharged and will be seen to bubble
- Equalisation prevents plate sulphation
- Sealed batteries should never be overcharged
- Inverter-chargers and top range charge controllers will do this autmatically

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Working on batteries

- Insulated tools
- Tools should be used correctly
- Tools should be placed on the ground when not in use
- Remove tool belts
- Remove jewellery

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Battery maintenance

Battery electrolyte needs to be kept topped up with de-ionised/distilled water

Battery terminals should be kept free of corrosion and protected with grease or petroleum jelly

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Commissioning new batteries

- Some new batteries are supplied dry. They need to be filled with sulphuric acid of the correct specific gravity
- Some are dry-charged and can be put into use immediately
- Others will need a commissioning charge. Details are given in battery manuals

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Recombination & flame-retardant caps

HOPPECKE AquaGen® premium.top with stand

HOPPECKE
POWER FROM INNOVATION


HOPPECKE two component cell plug

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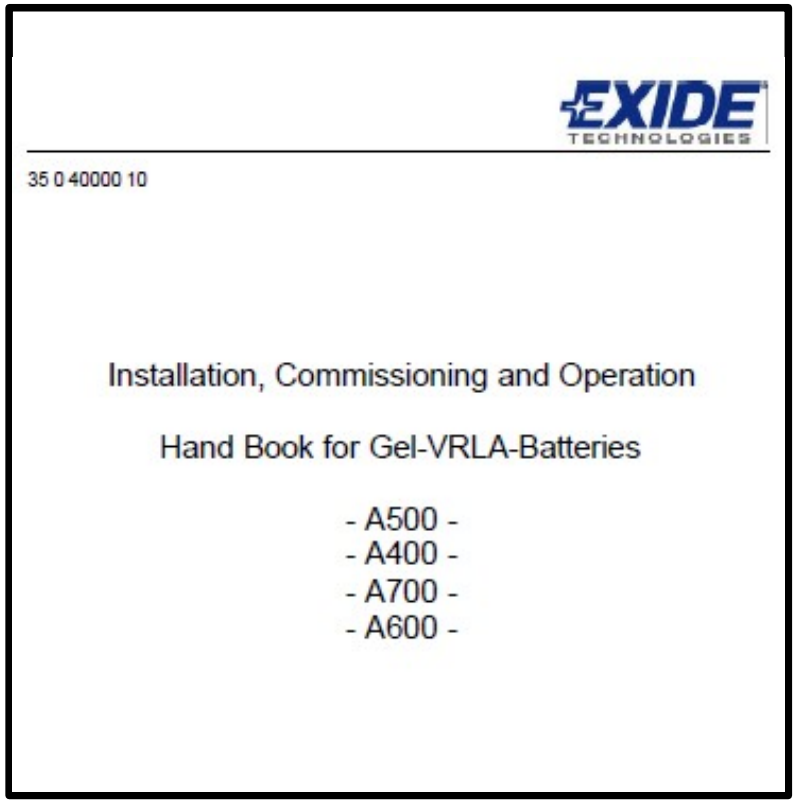
Battery manuals



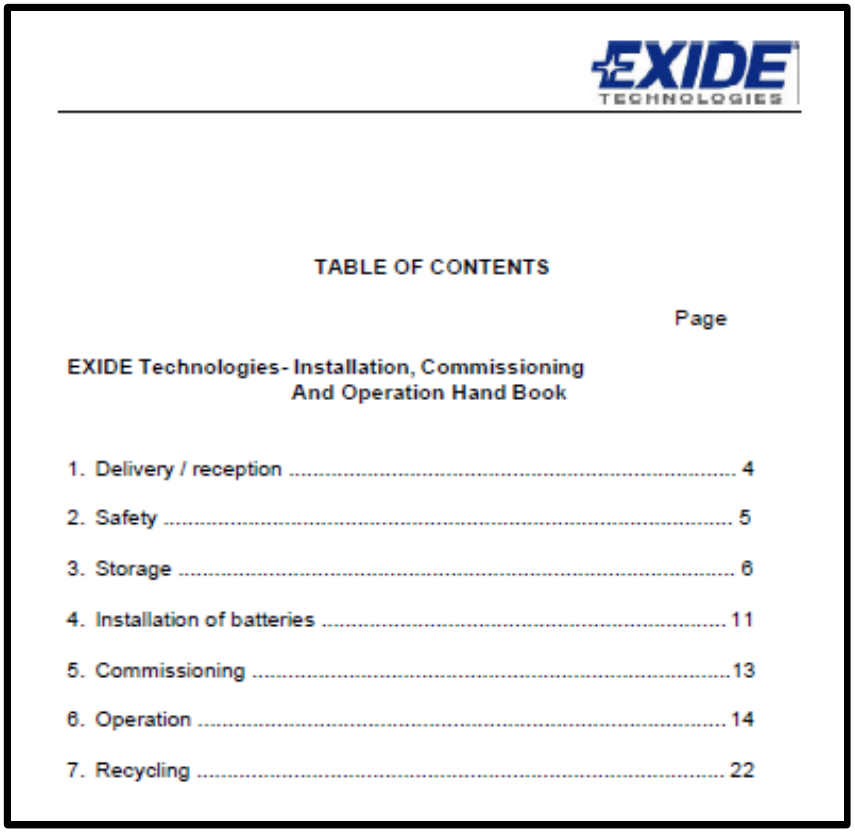
EXIDE TECHNOLOGIES

35 0 40000 10

Installation, Commissioning and Operation

Hand Book for Gel-VRLA-Batteries

- A500 -
- A400 -
- A700 -
- A600 -



EXIDE TECHNOLOGIES

TABLE OF CONTENTS

Page

This one from *Exide*, is 22 pages long

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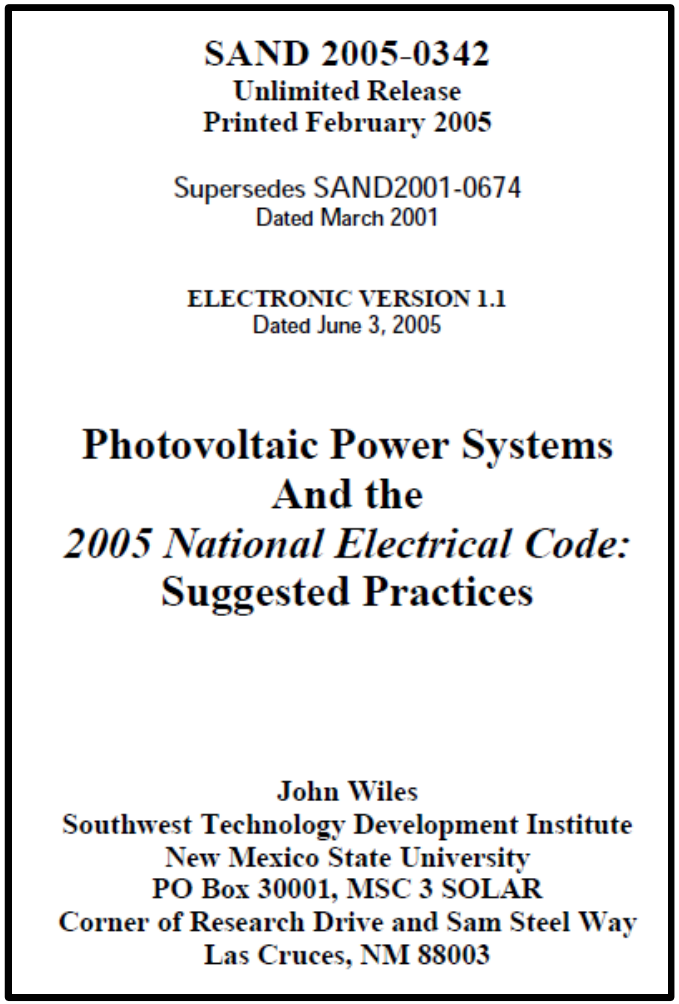
Codes?

- National code?
- Battery manuals are a good guide



SAND 2005-0342
Unlimited Release
Printed February 2005

Supersedes SAND2001-0674
Dated March 2001

ELECTRONIC VERSION 1.1
Dated June 3, 2005

Photovoltaic Power Systems And the *2005 National Electrical Code:* Suggested Practices

John Wiles
Southwest Technology Development Institute
New Mexico State University
PO Box 30001, MSC 3 SOLAR
Corner of Research Drive and Sam Steel Way
Las Cruces, NM 88003