

Battery Technology and Amateur Radio

DAVIE COOPER CITY
AMATEUR RADIO CLUB

DCARC

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Batteries

What type
of batteries
do I need
for Amateur
Radio?

Do I need
an
emergency
Battery
Go-Box?

How long
will my
battery last?

Is it safe to
work with
batteries, or
can I get
shocked?



Be Safe

Safety First

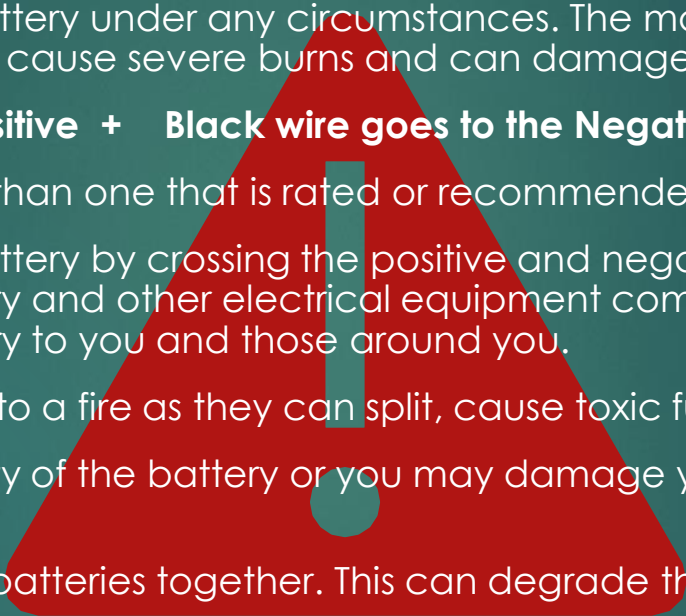
- ▶ Safety Glasses
- ▶ Gloves

<https://youtu.be/VswaFOrVM6I>

Any Lawyers in the room?



Safety

- 
- ▶ **Do this at your own risk?**
 - ▶ Never disassemble a battery under any circumstances. The materials in a battery are often toxic and can cause severe burns and can damage your clothing.
 - ▶ **Red wire goes to the Positive + Black wire goes to the Negative -**
 - ▶ Never use a fuse larger than one that is rated or recommended for your device
 - ▶ Do not short circuit a battery by crossing the positive and negative terminals as you can damage the battery and other electrical equipment components. This can cause burns and/or injury to you and those around you.
 - ▶ Never throw batteries into a fire as they can split, cause toxic fumes and leak acid.
 - ▶ Don't reverse the polarity of the battery or you may damage your equipment and the battery.
 - ▶ Don't use old and new batteries together. This can degrade the batteries.
 - ▶ **"Always"** charge the battery at the correct voltage and amperage after each use.
 - ▶ Don't over-charge the battery as this can damage the battery and cause it to leak.
 - ▶ Follow the manufacturers charging procedures.
 - ▶ Store batteries in a sealed, cool, dry place when not in use.

Rules

- ▶ Note:
 - ▶ With many rules - there are always exceptions.
 - ▶ There are hybrids and exceptions to all the examples I am showing in this presentation, but the concepts and information is based on the more common battery types available.

Battery Types

- ▶ Cranking ☒
 - ▶ High current output
 - ▶ Shorter discharge duration
 - ▶ Thinner plates
- ▶ Deep Cycle ☒
 - ▶ Lower current output
 - ▶ Longer duration
 - ▶ Thicker plates
- ▶ Hybrid
 - ▶ This is a balance of the two technologies
 - ▶ Slightly thicker plates
 - ▶ Slightly longer output duration



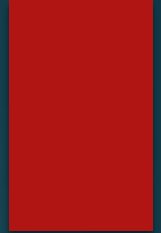
WHAT IS A CRANKING BATTERY?

- ▶ A cranking battery is the battery that allows a vehicle to start, sending power to the engine starter when the ignition switch is activated.
- ▶ These are also known as starting batteries.
- ▶ These are designed for high current in short bursts of energy.
- ▶ These have many thin plates to increase the surface area for the high current demands.
- ▶ The thin plates are a poor choice for continuous discharge loads.

WHAT IS A DEEP CYCLE BATTERY?

- ▶ This type of battery is designed to provide **continuous**, reliable power.
- ▶ Sometimes referred as a golf cart, trolling, or RV battery.
- ▶ A deep cycle battery, consists of fewer plates, but those plates are thicker.
- ▶ This allows the battery to provide continuous power output over longer periods of time without damaging the plates.
- ▶ It also means that the battery can be entirely drained (**not recommended**) and recharged many times over, which is not the case with cranking batteries.
- ▶ Deep cycle batteries are also less likely to overheat due to their thicker plate construction, which can withstand high temperatures during heavy current usage.

DUAL PURPOSE MARINE BATTERIES

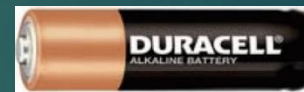


- ▶ With many rules - there are always exceptions.
- ▶ There are dual purpose batteries that can work for both cranking and trolling.
- ▶ Some smaller RV and boats will use these batteries to save space and weight.
- ▶ However, these dual-purpose batteries are not necessarily the right solution for most applications.
- ▶ Although they do serve the purpose of reducing maintenance, space, weight, and the number of batteries you need to purchase.
- ▶ Deep cycle batteries are built to withstand many deep discharges and recharges while cranking batteries are not.
- ▶ The compromise is a dual-purpose battery, therefore, falls somewhere in between the cranking and deep cycle needs.
- ▶ Most will not stand up well to total discharges (discharge beyond 50% of usable capacity).

Battery Categories

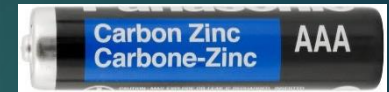
- ▶ The categories of batteries we use frequently in Amateur Radio Service are:

- ▶ Flashlight (Primary Cell)
- ▶ Rechargeable
- ▶ High Capacity (Lithium Ion)
- ▶ Large High Capacity
 - ▶ SLA
 - ▶ LIPO4
 - ▶ Lead Acid Float



Flashlight Battery Types

- ▶ Non Rechargeable
 - ▶ Carbon Zinc (heavy duty) 1.5 v
 - ▶ Alkaline 1.5 v
 - ▶ Lithium Primary 1.5 v (not rechargeable)
- ▶ Rechargeable
 - ▶ NiCad obsolete 1.2 v
 - ▶ Nickel Metal Hydride (NiMh) 1.2 v
 - ▶ Lithium rechargeable Li-ion (later section) 3.7v



Flashlight



- ▶ Non Rechargeable
 - ▶ AAA
 - ▶ AA
 - ▶ C
 - ▶ D
 - ▶ CR123
 - ▶ Lithium Primary (camera)
- ▶ Rechargeable
 - ▶ NiCad
 - ▶ NiMh
 - ▶ Lithium Polymer (LiPo)

Lithium Rechargeable (LiPo)

- ▶ High energy density
 - ▶ Low internal resistance
 - ▶ Tiny memory
 - ▶ Low self-discharge
 - ▶ +3.6 to 3.7v vs 1.2 to 1.5 v for standard batteries
 - ▶ Requires voltage regulation (14-15 v vs 13.8)
-
- ▶ Lithium Cobalt (LCO) 3.6 v
 - ▶ Lithium Manganese Cobalt Oxide 3.7 v
 - ▶ Lithium Iron Phosphate 3.2 v

LiPo Batteries

- ▶ The batteries will hold their charge longer compared to other rechargeable batteries
- ▶ They only lose about 5 percent a month. (20 percent NiMh)
- ▶ They don't have the same memory as other rechargeable batteries
- ▶ They can handle hundreds of charge and discharge cycles.

Lithium Cobalt (LCO) (LiPO) 3.6 v

- ▶ RC drones, planes, laptops, smart devices
 - ▶ High energy (Caution)
 - ▶ Higher voltage
 - ▶ Limited Load but higher current
 - ▶ Lower thermal stability (can catch fire) especially if damaged
 - ▶ Shorter lifespan
 - ▶ Li-cobalt should not be charged and discharged at a current higher than its C-rating
 - ▶ Being replaced by other more stable chemistries

Lithium Manganese Cobalt Oxide 3.7 v

- ▶ Low internal cell resistance
- ▶ Faster charging
- ▶ High discharge currents 20-30 A
- ▶ Power tools, medical equipment, and electric vehicles

Lithium Iron Phosphate

(LiFePO_4) LFP 3.2 v

- ▶ Li-phosphate offers good electrochemical performance with low resistance.
- ▶ The key benefits are high current rating and long cycle life, besides good thermal stability, enhanced safety and tolerance if abused.
- ▶ Li-phosphate is more tolerant to full charge conditions and is less stressed than other lithium-ion systems
- ▶ One important advantage over other lithium-ion chemistries is thermal and chemical stability, which improves battery safety
- ▶ As a trade-off, its lower nominal voltage of 3.2V/cell reduces the specific energy below that of cobalt-blended lithium-ion. (**better for Amateur Radio 13.2 v**)
- ▶ Li-phosphate has a higher self-discharge than other Li-ion batteries, which can cause balancing issues with aging.

Dual Carbon Battery (prototype)

- ▶ Power Japan Plus has announced an innovative new battery
- ▶ Charges 20 times faster
- ▶ Lasts longer and LI batteries
- ▶ Supposedly safer and cheaper
- ▶ Similar size
- ▶ Powerjapanplus.com
- ▶ <https://youtu.be/OJwZ9uEpJOo>
- ▶ <https://www.iflscience.com/technology/new-dual-carbon-battery-charges-20x-faster-lithium-ion/>

Higher Capacity Batteries

- ▶ Lead Float (car and marine)
- ▶ Gel Cell (aviation)
- ▶ Sealed Lead Acid (SLA/ AGM) (UPS and Alarm)
- ▶ Lithium Cobalt Phosphate (New)
- ▶ Lithium Iron Phosphate (New)
- ▶ Dual Carbon (Prototype)

Battery Capacity Measurements

- ▶ Voltage
 - ▶ Can provide an estimate on how much charge is left in the battery (note: Battery control boards may prevent accurate reading)
- ▶ Amperage or Milliamps (ma)
 - ▶ How much power is being drawn out of the battery
- ▶ Battery Capacity Rating
 - ▶ Amp Hour (Ah) or Milliamp hour (mAh)
 - ▶ Cold Cranking Amp (cca)
- ▶ Now the industry is using a newer “C” rating
 - ▶ There is a C rating is for both Charge and discharge
 - ▶ Charge rates
 - ▶ Discharge rates

Important: for safety and longevity of the batteries

Do not exceed the C rating on charge or discharge

C Rate

- ▶ Battery manufacturers specification sheets and labeling often list a batteries C ratings.
- ▶ To calculate the charge and discharge rate you would multiply a batteries capacity by the C rate
- ▶ As an example the Bioenno 12 ah battery is rated at 2 C on discharge providing 20 + amp of output.
- ▶ The batteries rated charge is 2 amps, so the charge C rate is .6 C

Lead Acid Charge Level

Voltage	State of Charge
12.6+	100%
12.5	90%
12.42	80%
12.32	70%
12.20	60%
12.06	50%
11.9	40%
11.75	30%
11.58	20%
11.31	10%
10.5	0%

SLA Charge Level

AGM BATTERY STATE OF CHARGE	
Level	Voltage
100%	13.00V
90%	12.75V
80%	12.50V
70%	12.30V
60%	12.15V
50%	12.05V
40%	11.95V
30%	11.81V
20%	11.66V
10%	11.51V
0%	10.50V

LiPo Charge Level

- Depends on the type of BCM

State Of Charge vs. Lipoly Pack Voltage						
% Capacity	1S Cell	2S Pack	3S Pack	4S Pack	5S Pack	6S Pack
100	4.20	8.40	12.60	16.80	21.00	25.20
95	4.15	8.30	12.45	16.60	20.75	24.90
90	4.11	8.22	12.33	16.45	20.56	24.67
85	4.08	8.16	12.25	16.33	20.41	24.49
80	4.02	8.05	12.07	16.09	20.11	24.14
75	3.98	7.97	11.95	15.93	19.92	23.90
70	3.95	7.91	11.86	15.81	19.77	23.72
65	3.91	7.83	11.74	15.66	19.57	23.48
60	3.87	7.75	11.62	15.50	19.37	23.25
55	3.85	7.71	11.56	15.42	19.27	23.13
50	3.84	7.67	11.51	15.34	19.18	23.01
45	3.82	7.63	11.45	15.26	19.08	22.89
40	3.80	7.59	11.39	15.18	18.98	22.77
35	3.79	7.57	11.36	15.14	18.93	22.72
30	3.77	7.53	11.30	15.06	18.83	22.60
25	3.75	7.49	11.24	14.99	18.73	22.48
20	3.73	7.45	11.18	14.91	18.63	22.36
15	3.71	7.41	11.12	14.83	18.54	22.24
10	3.69	7.37	11.06	14.75	18.44	22.12
5	3.61	7.22	10.83	14.43	18.04	21.65
0	3.27	6.55	9.82	13.09	16.37	19.64

Stay in the white region for maximum pack longevity

Battery Charging

▶ Low and Slow (12-16 hours)

- ▶ Check manufacturer of the battery for
 - ▶ Charge
 - ▶ Discharge specifications
- ▶ Smart Chargers
 - ▶ Take much of the guess work out of using the correct charging voltage and amperage
 - ▶ They also have multiple charging levels to protect the battery from damage and provide long life
 - ▶ Some chargers come with a desulfation mode

Battery Charging

- ▶ Flooded Lead Acid
 - ▶ Constant current, constant voltage (CC/CV)
 - ▶ about 13.8 to 14.4 v Float 13.2 - 13.4
 - ▶ 12 to 16 hours
- ▶ AGM
 - ▶ Sensitive to overcharging
 - ▶ Multistage charger to reduce over heating and prevent gassing
 - ▶ Charge 14.4 Float 13.5 - 13.8 v

Battery Charging

▶ Lead Acid(3 stage)

- ▶ Constant current, constant voltage (CC/CV)
- ▶ Bulk, absorption, float charge
- ▶ about 13.8 to 14.4 v Float 13.2 - 13.4
- ▶ 12 to 16 hours

▶ SLA /AGM

- ▶ Constant voltage variable current (CV/VC)
- ▶ Bulk*, absorption* , Float
- ▶ Sensitive to overcharging
- ▶ Multi stage charger recommended to reduce over heating and prevent gassing (Optional desulfate)
- ▶ Charge 14.4 Float 13.5 - 13.8 v

▶ LiPo

- ▶ Constant Current Constant Voltage (CC/CV)
- ▶ Some come with built in PCM/BCM (protection circuit module/battery control module) in the battery to protect from over charging and discharging the battery along with equalizing the cells
- ▶ Multistage smart charger or built in charging circuit recommended

LIFEPO4 BCM/ PCM

- ▶ Battery Control Module/ Protections Control Module
- ▶ These could be internal to the battery pack or external
 - ▶ Prevents over charging of batteries
 - ▶ Equalizes cells in the battery pack
 - ▶ Prevents drawing too much power
 - ▶ Prevents damaging the battery from over discharge

Proper Charging

- ▶ Single stage charger (Bulk)
 - ▶ Single output charge voltage and no shut off when fully charged
 - ▶ Can overcharge battery
 - ▶ Cause overheating and gassing
 - ▶ Premature battery failure



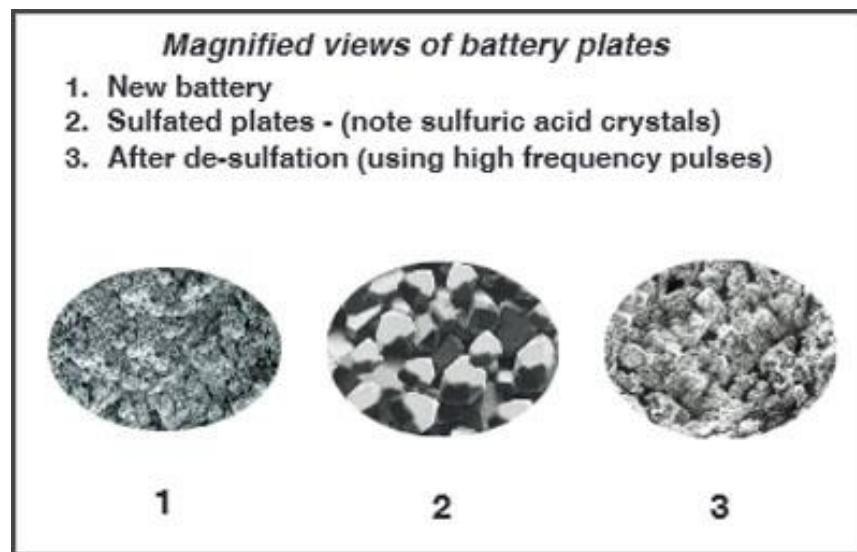
Proper Charging

- ▶ Multistage Charger (Low and Slow)
 - ▶ Bulk*
 - ▶ Absorption
 - ▶ Trickle
 - ▶ Float
 - ▶ De-sulfate



Sulfating/ Desulfating

- ▶ Batteries over time will sulfate and build up a layer of sulfur on the plates.
 - ▶ Causes
 - ▶ If they are not properly charged
 - ▶ Over charged
 - ▶ Under charged
 - ▶ Left uncharged
 - ▶ Age



Sulfating/ Desulfating

- ▶ Battery Sulfating
 - ▶ Loose of capacity
 - ▶ Taking longer to recharge
 - ▶ Battery discharges quicker
 - ▶ Battery gets hot during charges
- ▶ Smart charger often have a desulfating mode to recondition and remove the build up of sulfur on the plates by sending a pulse charge to the battery.

Battery Testing

- ▶ You only need to test your battery if
 - ▶ It begins to show signs of ageing
 - ▶ If you want to know how much life is left
 - ▶ If you pick up surplus batteries and don't know the age or capacity of the battery

Battery Testers

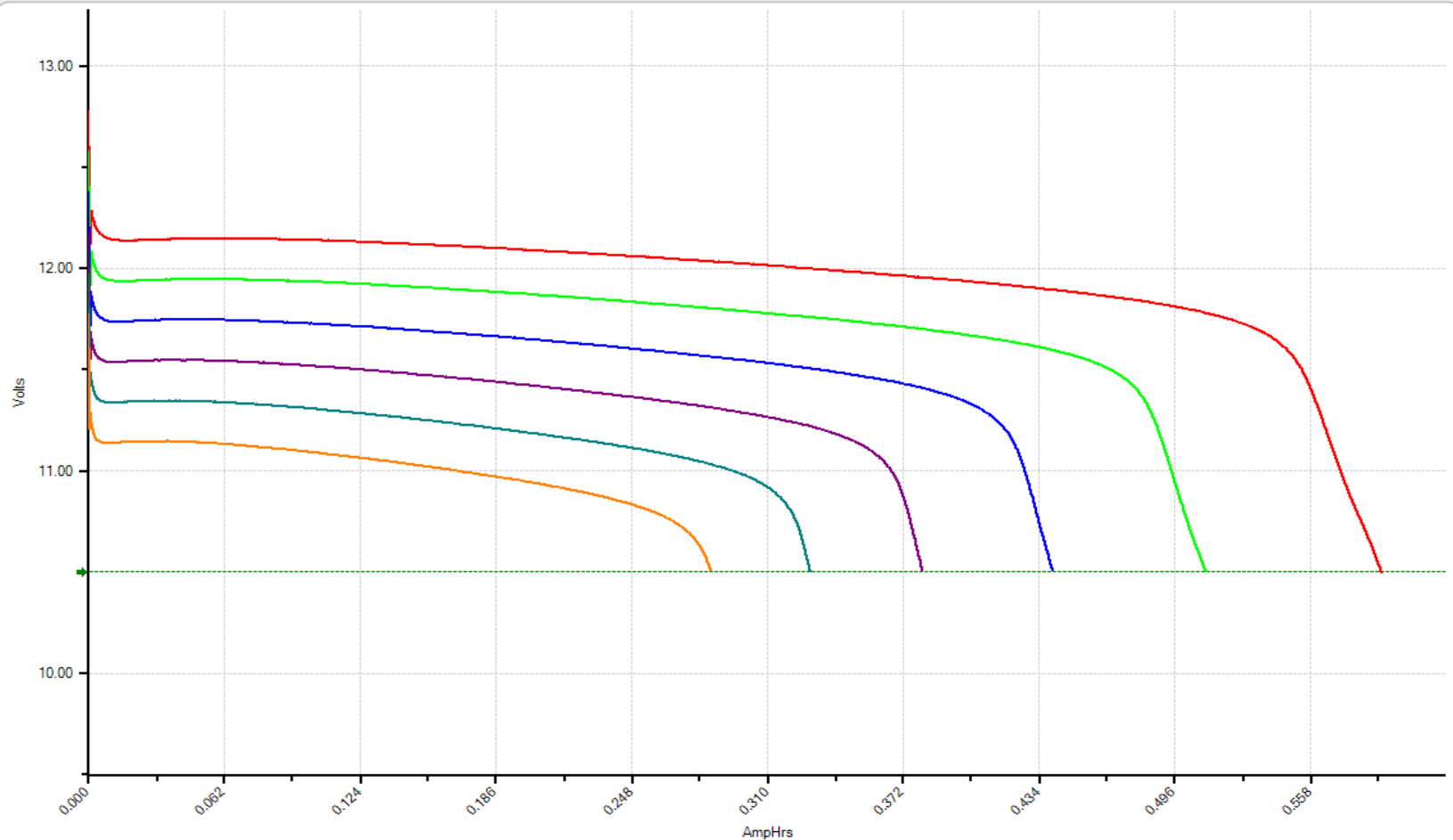
- ▶ Battery Tester
- ▶ West Mountain



West Mountain CBA

West Mountain Radio - Computerized Battery Analyzer (CBA)

Fresh: 6 Lead Acid cells, 1.0 Ah @ 0.40A Run2: 6 Lead Acid cells, 1.0 Ah @ 0.40A Run3: 6 Lead Acid cells, 1.0 Ah @ 0.40A
Run4: 6 Lead Acid cells, 1.0 Ah @ 0.40A Run5: 6 Lead Acid cells, 1.0 Ah @ 0.40A Run6: 6 Lead Acid cells, 1.0 Ah @ 0.40A



Battery Sources

- ▶ Amazon
- ▶ Electronic Surplus
- ▶ Alarm Companies
- ▶ Companies with Large UPS systems being decommissioned
- ▶ Telephone companies
- ▶ Government agencies
- ▶ Motorcycle LiPo
- ▶ Golf Carts for the larger batteries
 - ▶ **Careful:** some batteries are higher voltage

LiPo Suppliers

- ▶ Bioenno LiPo4
 - ▶ <https://www.bioennopower.com/>
 - ▶ Amazon
 - ▶ HRO
- ▶ Zippy LiFe
 - ▶ ZIPPY Flightmax 8400mAh 4S2P LiFePo4 Pack
 - ▶ https://hobbyking.com/en_us/zippy-flightmax-8400mah-4s2p-30c-lifepo4-pack-xt90.html
- ▶ K2 Energy LiFe ?
 - ▶ <https://k2battery.com/product/k2-lithium-ion-energy-battery-2/>
- ▶ Western Power Sports
 - ▶ <https://www.wps-inc.com/>
- ▶ Relion
 - ▶ <https://relionbattery.com/products/lithium>



Questions?

THANK YOU