Garland – Radio Amateur Civil Emergency Service – Training
Presented by Bob Brunskill – KC5GMZ

Thank you, _____ and good evening to the NET. This is _____.
Tonight's training is titled:

Batteries

You have most likely heard the term K.I.S.S. (Keep It Simple, Stupid). First, I am going to attempt to explain how lead acid batteries work and what they need without burying you with a bunch of needless technical data. Keep in mind that a lead acid battery can be open or not sealed like your car battery or it can be a sealed lead battery and used in a portable environment such as an event. The upcoming Garland Fourth of July event is a good example where a sealed lead battery might be used.

The commercial use of the lead acid battery is over 100 years old. The same chemical principal is being used to create energy that our Great, Great, Grandparents may have used.

If you can grasp the basics you will have fewer battery problems and will gain greater battery performance, reliability, and longevity. I will give you a URL at the end of the training session for additional information and easy reference.

A battery is like a piggy bank. If you keep taking out and putting nothing back you soon will have nothing.

Present day chassis battery power requirements are huge. Look at a new automobile and all the electrical devices that must be supplied. Electronics require a source of reliable power. Poor battery condition can cause expensive electronic component failure. Did you know that the average auto has 11 pounds of wire in the electrical system? Look at RVs and boats with all the electrical gadgets that require power. I can remember when a trailer or motor home had a single 12-volt house battery. Today it is standard to have 2 or 4 house batteries powering inverters up to 4000 watts.

Average battery life has become shorter as energy requirements have increased. Life span depends on usage; 6 months to 48 months, yet only one-third of all batteries actually reach the 48-month mark.

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A Few Basics

The Lead acid battery is made up of plates, lead, and lead oxide (various other elements are used to change density, hardness, porosity, etc.) with a 35% sulfuric acid and 65% water solution. This solution is called an electrolyte which causes a chemical reaction that produce electrons. When you test a battery with a hydrometer you are measuring the amount of sulfuric acid in the electrolyte. If your reading is low, that means the chemistry that makes electrons is lacking. So where did the sulfur go? It is stuck to the battery plates and when you recharge the battery the sulfur returns to the electrolyte.

1. We must think **safety** when we are working around and with batteries. Remove all jewelry. I have a permanent tattoo around my wrist where my watch band melted after completing a circuit with a car battery for only a second or two. Remember, it only takes a few seconds for a ring or a chain or a watch band to turn a glowing red when connected to a battery. The hydrogen gas that batteries make when charging is very explosive. I have had a motorcycle battery blow up and cover me in sulfuric acid. I couldn't get to the garden hose fast enough. That is no fun. This is a good time to use those safety goggles that are hanging on the wall. Sulfuric Acid eats up clothing or at the very least leaves white splotches on your clothes. Did you know that Polyester clothing is naturally acid resistant. Guys, there is hope for your old leisure suit after all. I just wear junk clothes, after all Polyester is so out of style. When doing electrical work on vehicles it is best to disconnect the ground cable. Just remember you are messing with corrosive acid, explosive gases and 100's amps of electrical current.

2. Basically there are **two types of batteries;** starting (cranking), and deep cycle (marine/golf cart). The **starting battery** is designed to deliver quick bursts of energy (such as starting engines) and have a greater plate count. The plates will also be thinner and have somewhat different material composition. The **deep cycle battery** has less instant energy but greater long-term energy delivery. Deep cycle batteries have thicker plates and can survive a number of discharge cycles. Starting batteries should not be used for deep cycle applications. The so-called **Dual Purpose Battery** is only a compromise between the 2 types of batteries. Every time you completely discharge a standard car battery you shorten its life significantly.

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3. Wet Cell (flooded)**, Gel Cell, and Absorbed Glass Mat (AGM)** are various versions of the lead acid battery. The **wet cell** comes in 2 styles; serviceable, and maintenance free. Both are filled with electrolyte. You may prefer one that you can add water to and check the specific gravity of the electrolyte with a hydrometer. The **Gel-Cell** and the **AGM** batteries are specialty batteries that typically cost twice as much as a premium wet cell. However they store very well and do not tend to sulfate or degrade as easily or as easily as wet cell. There is little chance of a hydrogen gas explosion or corrosion using these batteries, these are the safest lead acid batteries you can use. Gel-Cell and some AGM batteries may require a special charging rate. I personally feel that careful consideration should be given to the AGM battery technology for applications such as Amateur Radio, Marine, RV, Solar, Audio, Power Sports and Stand-By Power just to name a few. If you don't use or operate your equipment daily; which can lead premature battery failure; or depend on top-notch battery performance then spend the extra money. Gel-Cell batteries still are being sold but the AGM batteries are replacing them in most applications. There is a little confusion about AGM batteries because different manufactures call them different names; a couple popular ones are regulated valve and dry cell batteries. In most cases AGM batteries will give greater life span and greater cycle life than a wet cell battery.

The AGM batteries we sell are typically good deep cycle batteries and they deliver best life performance if recharged before the battery drops below the 50 percent discharge rate. If these AGM batteries are discharged to a rate of 100 percent the cycle life will be 300 plus cycles and this is true of most AGM batteries rated as deep cycle batteries. The Gel Cell battery is the better very deep cycle battery in life performance when full discharge applications must be considered. Gel Cell batteries do require special charge requirements and a battery charger with proper setting must be used.

4. CCA, CA, AH and RC what are these all about? Well these are the standards that most battery companies use to rate the output and capacity of a battery.

Cold cranking amps **(CCA)** is a measurement of the number of amps a battery can deliver at 0 degrees F for 30 seconds and not drop below 7.2 volts if it is a 12 battery. So a high CCA battery rating is good especially in cold weather.

CA is cranking amps measured at 32 degrees F. This rating is also called marine cranking amps**(MCA)**. Hot cranking **amps (HCA)** is seldom used any longer but is measured at 80 degrees F.

Reserve Capacity **(RC)** is a very important rating. This is the number of minutes a fully charged battery at 80 degrees F will discharge 25 amps until the battery drops below 10.5 volts.

Amp hours **(AH)** is a rating usually found on **deep cycle**, **Gel Cell, and Absorbed Glass Mat (AGM)** batteries . If a battery is rated at 100 amp hours it should deliver 5 amps for 20 hours, 20 amps for 5 hours, etc.

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5. Battery Maintenance is an important issue. The battery should be cleaned using a baking soda and water mix. Cable connections need to be checked, clean and tightened often. Many battery problems are caused by dirty and loose connections. A serviceable battery needs to have the fluid level checked. Use only mineral free water. Distilled water is best. Don't overfill battery cells especially in warmer weather. The natural fluid expansion in hot weather will push excess electrolytes from the battery. To **prevent corrosion** of cables on top post batteries use a small bead of silicon sealer at the base of the post and place a felt battery washer over it. Coat the washer with high temperature grease or petroleum jelly (Vaseline), then place the cable on the post and tighten. Coat the exposed cable end with the grease. Most folks don't know that just the gases from the battery condensing on metal parts causes most corrosion.

6. Battery Testing can be done in more than one way. The most popular is measurement of specific gravity and battery voltage. To measure specific gravity buy a temperature compensating hydrometer at an auto parts store. To measure voltage, use a digital D.C. Voltmeter.

You must first have the battery fully charged. The surface charge must be removed before testing. If the battery has been sitting at least several hours (I prefer at least 12 hours) you may begin testing. To remove surface charge a car battery must experience a load of 20 amps for 3 plus minutes. Turning on the headlights (high beam) will do the trick. After turning off the lights you are ready to test the battery.

State of Charge	Specific Gravity	Voltage	
		12V	**6V**
100%	1.265	12.7	6.3
*75%	1.225	12.4	6.2
50%	1.190	12.2	6.1
25%	1.155	12.0	6.0
Discharged	1.120	11.9	6.0

*Sulfation of Batteries starts when specific gravity falls below 1.225 or voltage measures less than 12.4 (12v Battery) or 6.2 (6 volt battery). Sulfation hardens the battery plates reducing and eventually destroying the ability of the battery to generate Volts and Amps.

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Load testing is yet another way of testing a battery. Load test removes amps from a battery much like starting an engine would. A load tester can be purchased at most auto parts stores. Some battery companies label their battery with the amp load for testing. This number is usually 1/2 of the CCA rating. For instance, a 500CCA battery would load test at 250 amps for 15 seconds. A load test can only be performed if the battery is near or at full charge.

The results of your testing should be as follows:

> Hydrometer readings should not vary more than .05 difference between cells.
>
> Digital Voltmeters should read as the voltage is shown in this document. The sealed AGM and Gel-Cell battery voltage (full charged) will be slightly higher in the 12.8 to 12.9 ranges. If you have voltage readings in the 10.5 volts range on a charged battery, that indicates a shorted cell.
>
> If you have a maintenance **free wet cell,** the only ways to test are voltmeter and load test. Most of the maintenance free batteries have a built in hydrometer that tells you the condition of 1 cell of 6. You may get a good reading from 1 cell but have a problem with other cells in the battery.

When in doubt about battery testing, call the battery manufacturer. Many batteries sold today have a toll free number to call for help.

7. Selecting a Battery - When **buying a new battery** I suggest you purchase a battery with the greatest reserve capacity or amp hour rating possible. Of course the physical size cable hook up and terminal type must be a consideration.

For Radio Amateur use you may want to consider a Gel-Cell or an Absorbed Glass Mat (AGM) rather than a Wet Cell as the application is in a harsher environment and the battery is not going to receive regular maintenance and charging. In general for every ampere hour you will add a pound in weight. For example, a twelve ampere hour battery will weigh twelve pounds.

Be sure to purchase the correct type of battery for the job it must do. Remember an engine starting battery and deep cycle batteries are different. **Freshness** of a new battery is very important. Give that consideration when you go to HamCom and see a battery on the tailgate of someone's pickup. The longer a battery sits and is not re-charged the more damaging sulfation build up there may be on the plates. Most batteries have a date of manufacture code on them. The month is indicated by a letter 'A' being January and a number '9' being 1999. C8 would tell us the battery was manufactured in March 1998. Remember the fresher the better. The letter "i" is not used because it can be confused with #1.

Battery warranties are figured in the favor of battery manufactures. Let's say you buy a 60-month warranty battery and it lives 41 months. The warranty is pro-rated so when taking the months used against the full retail price of the battery you end up paying about the same money as if you purchased the battery at the sale price. This makes the manufacturer happy. What makes me happy is to exceed the warranty. Let me assure you it can be done.

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8. Battery life and performance - Average battery life has become shorter as energy requirements have increased. Two phrases I hear most often are **"my battery won't take a charge, and my battery won't hold a charge".** Only one-third of the car batteries sold today reach the 48-month mark. In fact 80% of all battery failure is related to sulfation build-up. This build up occurs when the sulfur molecules in the electrolyte (battery acid) become so deeply discharged that they begin to coat the battery's lead plates. Before long the plates become so coated that the battery dies. The causes of sulfation are numerous. Let me list some for you.

- Batteries sit too long between charges. As little as 24 hours in hot weather and several days in cooler weather.
- Battery are stored without some type of energy input.
- "Deep cycling" an engine starting battery. Remember these batteries can't stand deep discharge.
- Undercharging of a battery, to charge a battery (let's say) to 90% of capacity will allow sulfation of the battery using the 10% of battery chemistry not reactivated by the incomplete charging cycle.
- Heat of 100 plus F., increases internal discharge. As temperatures increase so does internal discharge. A new fully charged battery left sitting 24 hours a day at 110 degrees F for 30 days would most likely not start an engine.
- Low electrolyte level - battery plates exposed to air will immediately sulfate.
- Incorrect charging levels and settings. Most cheap battery chargers can do more harm than good. See the section on battery charging.
- Cold weather is also hard on the battery. The chemistry does not make the same amount of energy as a warm battery. A deeply discharged battery can freeze solid in sub zero weather.

There are ways to greatly increase battery life and performance.

An example: Let's say you have "toys"; **extra radios, a classic car, a boat, etc.** You most likely don't use these toys 365 days a year as you do your car. Many of these toys are seasonal so they are stored. What happens to the batteries? Most batteries that supply energy to power our toys only last a couple of seasons. You must keep these batteries from sulfating or buy new ones. There are products to prevent and reverse sulfation. Using a pulse technology you can sometimes reverse and prevent of sulfation. Also solar powered trickle chargers are a great option for battery maintenance.

Parasitic drain is a load put on a battery with the key off. This also occurs in numerous Hand Held Amateur Radios. My Icom T2H manual warns about leaving the battery pack installed for long periods of time without recharging or replacing the AA cells. Vehicles have clocks, engine management computers, alarm systems, etc. In the case of a boat you may have an automatic bilge pump, radio, GPS, etc. These devices may all be operating without the engine running.

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9. Battery Charging - Remember you must put back the energy you use immediately. If you don't the battery sulfates and that affects performance and longevity. Your car alternator is one form of a battery charger. The wall wart that comes with your Hand Held is also a battery charger. The alternator works well if the battery is not deeply discharged. The alternator tends to overcharge batteries that are very low and the overcharge can damage batteries. In fact an engine starting battery on average has only about 10 deep cycles available when recharged by an alternator. Batteries like to be charged in a certain way, especially when they have been deeply discharged. This type of charging is called 3 step regulated charging. Please note that not all chargers are capable of regulated charging. Only special smart chargers that use computer technology can perform multiple step charging techniques. It is important not to boil or heat batteries at any time by excessive charge rates. Gel cell and AGM batteries require special considerations when recharging.

In summary, to properly charge a battery, you should apply a voltage that causes current to flow *(being careful to get the plus and minus hooked up properly!)* at about 1/10th the amp/hour rating of the battery to a maximum of about 1/4th the amp hour rating of the battery.

10. Battery Do's

- Think Safety First.
- Do regular inspection and maintenance especially in hot weather.
- Do recharge batteries immediately after discharge.
- Do buy the highest **RC** reserve capacity or **AH** amp hour battery that will fit your configuration.

11. Battery Don'ts

- Don't forget safety first.
- Don't add new electrolyte (acid).
- Don't use unregulated high output battery chargers to charge batteries.
- Don't place your equipment and toys into storage without some type of device to keep the battery charged.
- Don't disconnect battery cables while the engine is running (your battery acts as a filter).
- Don't put off recharging batteries.
- Don't add tap water as it may contain minerals that will contaminate the electrolyte.
- Don't discharge a battery any deeper than you possibly have to.
- Don't let a battery get hot to the touch and boil violently when charging.
- Don't mix size and types of batteries.

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More About Batteries

Modern batteries contain calcium metal in the lead to decrease the tendency to produce hydrogen gas during charging by electrolysis of the water in the electrolyte solution. If enough calcium metal is present, the battery gassing is so well controlled that the cells can be "sealed" and their demand for replacement water greatly decreased.

Another common type of rechargeable battery is a NiCad, based on Nickel Cadmium electrochemistry. Because they are a different chemistry, they have a different voltage. Dry cells, lead/acid cells and NiCad cells will all produce a different voltage ranging from about 1.3 volts fully charged to 2.1 volts fully charged. NiCads are often physically the same size as carbon/zinc "dry cells" and are made in double A, and C and other common sizes. But they will have a different voltage, a lower one. Usually this is not a problem for most electronics that are tolerant about the exact input power required. Some devices will insist that you use batteries of a certain type

All batteries or cells within a battery have an internal resistance and a capacity. The internal resistance determines how many amps the battery can reliably provide in service. The capacity is measured in amp/hours. This is simply the number of amps the battery can deliver at a reasonable discharge rate for that battery, and how many hours it is expected to deliver those amps.

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Battery Math and Amp/Hours

Most batteries are rated in electrical capacity for a discharge rate of 20 hours. A 20 **amp/hour** battery should provide one amp of current for 20 hours before being fully discharged. It will still show a voltage, it will no longer be functioning correctly and if rechargeable, it will be in serious need of a recharge.

Some smaller batteries like those used on HandiTalkies are rated in **milliamp/hours**. It is the same concept, they just use milliamps instead of amps for these lighter duty batteries. A typical rating might be 1200 ma/Hr which is the same as 1.2 amp/hour.

It is worth noting that a car battery has enough electric power in it to electrocute you many times over. The reason it does not is skin resistance. It takes about 48 volts to puncture the dry skin resistance of the human body and get current flowing in the conductive juices inside. Even damp skin will not breakdown easily at low voltages. This is why you can handle jumper cables hooked to a battery and usually not electrocute yourself, the voltage is too low to get the current inside the body where it can do damage. Still you should be careful about getting across any heavy duty electrical power circuit regardless of voltage.

It is quite reasonable to discharge a battery at its amp/hour rating divided by six, or four, or maybe even three. So a 45 amp/hour battery could be used to power something that demanded 10 or 12 amps. *But do not expect it to last four hours.* These higher demand currents will cause extra loses in the internal resistance of the battery to go up, and the total capacity before the battery is fully discharged will be less at these higher rates. More power is lost heating up the battery for instance.

So, if you divide a battery's amp/hour rating by the current load you are going to put on it, you can estimate how long it will last. If you divide a battery's amp/hour rating by 20, you will find out how much current it can deliver and still live up to its capacity rating. If you divide a battery's amp/hour rating by four, you can estimate the maximum current you should expect such a battery to deliver and still have a reasonable life expectancy before it is fully discharged.

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Gel Cell, and Absorbed Glass Mat (AGM) batteries are handy for portable operation. A typical one would be rated at 12 amp/hours. That means it can handle half an amp easily and work for 24 hours. It should not be asked to deliver more than 3 amps maximum. Let's assume that your radio that demands 2.0 amps on key down transmit and about .5 amps on receive. A 12 amp/hour **Gel Cell, or Absorbed Glass Mat (AGM)** battery can easily kept you going for 30 hours of a given event, assuming that most of the time was receive and not key down. The battery will still be healthy, but definitely ready for a recharge afterwards.

That same battery when asked to power a rig that demands six amps, will strangle, the voltage will drop dramatically and the power output from the rig will be unacceptable. For a discharge rate of six amps, something more like a 32 amp/hour battery is appropriate. Remember, that battery will weigh about 32 pounds.

Things to Know About a Battery

The three most important things to know about a battery, regardless of whether it is for an HT, a large HF portable station or just an AA size NiCad, are its **amp/hour rating**, its **chemistry** and its **voltage**. The chemistry determines the voltage of a cell and the number of cells determines the voltage of the battery. A standard car battery is six lead/acid cells in series. A standard "battery" for a flashlight is actually a single carbon/zinc cell. A typical automatic camera battery is two specially modified carbon/zinc cells in series to produce about three volts, etc.

Recharging a battery that can be recharged is easy to understand. You need to apply an appropriate voltage and current for an appropriate time. If a battery has a 12 amp/hour rating, you should expect to charge it at 1 amp for 12 hours, amazing how that works out!

The approximately correct charging rate for a battery is the amp/hour rating divided by 10. If you charge faster you will heat up the battery. Fast charging is OK as long as it is not overdone, like at the amp/hour rating divided by ONE. The amp/hour rating divided by four is OK if the battery is monitored or if a special charging circuit that limits the current and maximum voltage is used.

The correct charging voltage is determined by the chemistry of the cells and the number of cells in the battery. A typical car battery has six lead/acid cells. Such a cell puts out about 2.1 volts when fully charged. *SURPRISE!* six of them in series causes it to be called a 12.6 volt battery! However, when really fully charged and just off the charger, such a battery can be closer to 13.8 volts. Most car battery eliminators such as the Astron regulated power supplies will crank out a fixed 13.8 volts. This is why you keep seeing this pop up like some "Magic Number". 13.8 volts has become a standard input for Ham Radio rigs for this simple reason.

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Keep in mind this simple formula, called the "Power Law" :

AMPS times VOLTS equals WATTS.

So for a fixed amount of watts required or desired, if the volts go down, the amps have to go up. For that reason, rigs designed to work on "12 volt" power supplies, specifically for Car battery systems for mobile use etc., work better on 13.8 volts since they require less amps to get the same power input demand. That is another reason why most battery substitute A/C line driven power supplies, even though called "12 volt supplies" actually crank out a fixed 13.8 volts.

By the same token, if a battery drain is excessive, the internal resistance drags down the voltage. The net result is that the amps demanded goes up in a vicious cycle. This is why there is a reasonable maximum drain you should expect from any battery, based on its amp/hour capacity.

The power in a battery can be impressive. Take a standard car battery. It is rated at 45 amp/hours. That means it can crank out 2.25 amps for 20 hours. Also it will start out at about 12.9 volts and drop to about 11 volts, averaging about 12 volts during the period. 2.25 amps times 12 volts equals 27 watts. 27 watts times 20 hours equals 540 watt/hours, a half a kilowatt/hour, not bad at all for portable power.

How Large a Battery is Needed?

It is important to know how many amps your rigs draw in order to estimate how big a battery you are going to need. The manuals will give you a wild guess. It really needs to be measured. Such measurements are best done with the rig connected to an adequately rated, voltage regulated power supply like an Astron.

If you meter has a heavy duty amps scale, it can be hooked in series with the rig and you can read it directly. If not you need a series resistor. Remember that:

AMPS times OHMS equals VOLTS

so if one knows how many ohms the resistor is and you measure how many volts of drop there are across it, you can easily calculate the amps.

You do not want a lot of voltage drop! or resistance in series in this application. Also you need a beefy resistor for the high power measurements and a DVM with an accurate scale that can measure millivolts. I use a 200 watt by .01 ohm precision resistor. Yes, that is one hundredth of an ohm! It is a huge device with big lugs on the end and can easily measure current draws of 50 amps or more, converting currents to easily read voltage drops in the millivolt range..

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A typical 100 watt HF transceiver is going to demand 20 to 25 amps. You can see at once that you are going to need a **BIG battery** for this. In a car, the alternator and not the battery powers the rig when the motor is running. Using the HF rig without the battery running at these power levels will strand you beside the road fairly fast.

You can also make a wild guess at the power required for any rig if you have a good idea of its transmit power. Take the rated power output, assume about 33% total efficiency so take that times three, and compute how many amps are needed to make that many watts at 12.6 volts. For instance, a rig designed to crank 100 watts is: 100 * 3 = 300 watts 300 watts/12.6 volts equals about 24 amps. If you are lucky and the rig is well designed it should need a bit less than this on key down CW transmit.

To take such a rig to the field you are looking at 80 to 100 amp/hours of battery minimum, two Car batteries in parallel, or one really beefy heavy equipment, or large marine battery. I have seen batteries easily available at up to 120 amp/hours each, but they are whoppers and back breakers to pick up.

Many batteries today are rated in **CCA** or **RC**. CCA is Cold Cranking Amps. CCA is approximately equal to the RC of a battery times five. [1000 CCA is about 190 RC]. RC is Reserve Capacity. You can convert RC to amp/hours by the following formula:

Amp/Hours = (Reserve Capacity / 2) plus 16

One solution to battery mass, is to turn down the power on the rig for portable service [QRP]. Few will notice if you reduce power from 100 watts to 50 or 25 watts, but you will decrease the power demand on transmit and the size of the battery sharply. This is a case where the FCC precept that you use the minimum power required to communicate makes a lot of sense.

In an emergency, a few S units on someone's distant receiver sacrificed for additional hours of operation on your end could be crucial. Remember battery life is not linear, if you half the power demand you may well more than double your operating time. Also remember that reducing power six DB, or to one fourth the transmit power, will only cut your received signal strength by one S unit on the other end.

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Are there any questions or anyone that needs a fill?

Thank you, this is _____.

I now return the net to Net Control.