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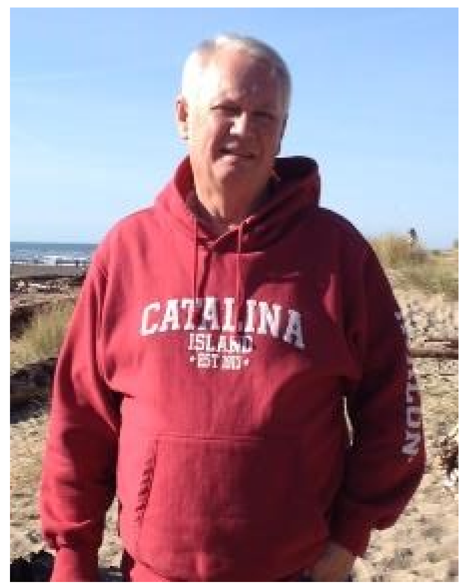


My good friend and mentor, Dennis McMahon recently reminded that I need to submit an article for this month's newsletter. I think about this for several days, wondering about what I am going to say to a club populated primarily by SME's (subject matter experts) in the model flying/building arena. I do not suffer from any delusions of grandeur about the position of president, and if I say or suggest something that touches some raw nerves, such as safety, it was done so out of needing to sense where the club is on a particular topic. When my brother Joe suggested that I should become presidents I let him know that I was not interested in just being a 'warm body', filling a slot because someone had to do it. I am in a somewhat steep learning curve while building my current project airplane, and this holds true as far as being your president. I am always willing to listen to new ways of doing things as far as our club goes, so please do not hesitate to approach me with your ideas. Please know that your executive committee will take every suggestion seriously. I do need to say that I am very gratified to see how many of you have been flying on a regular basis, and that the numbers of members who show up for work parties is very impressive. Nice to be involved with a club where the 80-20 rule for participation is not followed.

On another note, we have almost completed the building of the lower wing for my Curtis P6-E Hawk, biplane. It took us some time to figure out the operation of the pushrods and bellcranks on the lower wing, and how they

Continued on P. 2

function to move the ailerons in the upper wing. There is a bellcrank that sits horizontal in the wing which connects to another bellcrank that sits vertical in the wing. The vertical bellcrank then attaches. via a stiff wire, to the upper wing bellcrank that operates the ailerons, at least that is how it appears to function according to the plans. I am guessing that this may take some intense tuning to make the ailerons do what they need to do in a stable fashion. Another hurdle for another day. It has been good for me to still be employed, and to find time, mostly on the weekends with some weeknights in between to work on this plane. I have learned to be patient, with many sessions of being sure that parts will fit as they are designed to do before the glue bottle gets opened. As I mentioned in an earlier article, the kit dates back to c1954 where die cut was the state of the art, and not laser cut as most kits use today. The picture shows the lower wing, specifically focusing on the placement of the lower wing bellcranks. You engineers may have some ideas on why the design to move the ailerons was set this way.

Finally, we have some club events coming up in the next several months. Your executive committee members will support all of these activities in their roles as leaders, but do not intend to become solely responsible for being event coordinators. Now is the time for you to champion the event of your choice, and the executive committee will support you with helping plan these events. I have shared a template with the executive committee which should be very useful in organizing each activity.

CAVU to you all,

Jack

Safety Matters!

By Andy Niedzwiecke, BAM Safety Officer

Hi BAM members! As your new safety officer, let me introduce myself. I have been in the hobby since 1979 and a member of BAM since 1992. I have built and flown nitro models and now fly electric only.

As I was pondering this month's safety column, I was made aware of a recent incident at the field that I thought was worth addressing.

As we get ready for the flying season we should be aware that our planes have set for awhile or we are going to maiden new ones. A good practice to adhere to is make sure that your plane is airworthy and all controls behave as they are intended before bringing it to the field.

Here's a few suggestions/reminders to pay attention to:

1. Make sure, if you are working with an electric, that you remove the prop before attaching a battery. A prop is a serious knife blade when it is spinning.

2. Make sure your motor is spinning in the right direction. If it is not you can easily switch anytwo wires from the ESC to the motor and the problem is resolved.

3. Make sure you check your CG! This is very important to allow for proper smooth controllable flight.

4. Make sure all controls and surfaces are moving in the right direction.

5. Be sure to use throttle cut and make sure it works.

6. Make sure your batteries, both plane and transmitter are fully charged.

Please do not come to the field un-prepared. Remember you are sharing our field with 54 other members and safety is not an accident. Personal responsibility is always required.

Do You Know Your LiPo Batteries?

By Waldemar Frank

A few words from the author

This is a reissued article that I first wrote for our club newsletter in September 2013. After being asked to write another article about LiPo batteries for our current newsletter issue, I thought that the information in my original article is still valid. So instead of writing something from scratch, I decided to refurbish most of the original article—with some revisions—and add a section about internal resistance (IR). IR in particular has been and continues to be a passionately debated topic among hobbyists, mainly because understanding IR provides answers about your batteries' health and performance over time. There are many online and printed resources available to learn more about LiPo batteries. For example, a recent issue of AMA's ***Model Aviation*** *magazine featured another article about LiPo batteries (see March 2022 issue: "LiPo Batteries—Considerations for battery longevity," by David Buxton).*

Introduction

Electrics have established themselves as a go-to choice for many new hobbyists—mostly because of their ease of use and suitability for cost-effective entry-level foam planes. But even many seasoned hobbyists have added electrics to their collection due to the improved overall performance and extended flight times that LiPos offer compared to older battery technologies.

LiPos, or more specifically Lithium Polymer batteries, were originally designed to power electronic devices such as cell phones, calculators, watches, laptops, etc. The initial battery design for these devices involved lithium-ion batteries, which were eventually replaced by LiPos.

To make LiPos suitable for use with RC airplanes, manufacturers had to make design changes. These changes offer capacities and current discharge rates that can deliver the necessary power and flight times expected by most hobbyists.

Lithium, the lightest among the solid metals, has an extremely low melting point of only 180.5 °C (357 °F). To allow the flow of electrons (create electricity), the lithium-salt electrolyte is held in a solid polymer composite, hence the name **Lithium Polymer**. Interestingly, Lithium is also used as an anti-depressant ingredient in some medications. For our application though, its low weight is one main reason why LiPos can deliver such high energy relative to their weight compared to older battery types such as NiCd and NiMH.

However, good performance comes with a price: Lithium has also violent reactive characteristics, which require special care in its handling. When on fire, it produces corrosive and toxic fumes. Further, it aggressively reacts with water and has explosive tendencies. Thus, these tendencies should be taken into account when dealing with LiPos.

A typical configuration of a LiPo battery for RC applications includes one or more cells that are connected in series and/or in parallel. Each cell has a nominal voltage of 3.7 volts and up to 4.2 volts when fully charged. For example, a 3-cell battery (e.g., 3 cells connected in series) has a nominal voltage of 11.1 volts (3 x 3.7 V = 11.1 V) and 12.6 volts (3 x 4.2 V = 12.6 V) when fully charged.

The first LiPo batteries only included the battery leads—a balance connector was added as a safety feature once it became clear that LiPo batteries could ignite due to overcharging. Because each cell has its own physical characteristics, charging LiPos requires balancing of the voltage per cell to ensure that no cell is being overcharged (in excess of 4.2 volts), which could lead to sudden combustion and fire. Equally important, to ensure longevity in LiPo batteries one should not discharge individual cells below 3.3 volts.

Following is a summary of the key information used for labeling LiPo batteries. Please note that the arrangement of the information can vary by manufacturer:

1 **Manufacturer/brand name**

2 **Brand battery category**

3 The **capacity** of the battery expressed in milli Ampere hours or simply Ampere hours. This is the current the battery could supply for one hour (less time if a load is applied). In the above example, this battery has a capacity of 3,000 mAh or 3 Ah.

The capacity can be viewed as the "size of the electric fuel tank." That is, the higher the capacity, the longer the flight time when used with the same motor and propeller configuration. A bigger propeller (diameter and/or pitch) draws a higher current and therefore depletes the energy more quickly, hence reducing the flight time. The same applies when a more powerful motor is used on the same airplane.

The theoretical flight time (in minutes) can be calculated as follows:

(Capacity of battery x 60) / Current draw of motor-propeller configuration

Example:

3 Ah (3,000 mAh) LiPo battery with motor-propeller configuration that pulls 30 A at full throttle:

(3 Ah x 60) / 30 A = 180 / 30 = 6 minutes

Please note that most flights don't involve full throttle and the actual flight time can be longer. In addition, you typically do not want to discharge the battery below 20% of its total capacity after a flight. This ensures the longevity of your battery and retains enough capacity for a go-around if needed to land safely or to wait for other airplanes to land first.

I have my timer set to go off when there is roughly 25%-30% capacity left. You can experiment with your setup and perform some test flights to determine the approximate timer setting based on your preferred flying style (leisurely vs. aggressive). In general, I found this to be a good rule of thumb to balance flight time, fun, and risk of power drop.

Example: Let's assume that you deplete 70% of the battery capacity before landing. The approximate flight time would be as follows at full throttle:

$$(3 \text{ Ah} \times 0.7 \times 60) / 30 \text{ A} = 180 / 30 = 4.2 \text{ minutes} = 4 \text{ min. } 12 \text{ sec.}$$

Many motor manufacturers provide information about different propeller and cell configurations as well as the corresponding maximum current draw for that configuration. You can use this data to determine which battery size, propeller, and speed control work best for your specific airplane and application.

4 The **C-rating** indicates the maximum discharge rate of the battery. For example, 1C means that a battery can provide a maximum continuous current discharge rate of 1 x capacity. The above battery has a C-rating of 25, meaning that it can provide a continuous current of 25 x 3 A = 75 A.

Some manufacturers list a range such as 25-50 as shown in the above example. The second value indicates the maximum burst discharge rate. In the example, the battery could provide a burst discharge rate of 50 x 3 A = 150 A. However, the burst discharge rate can be supplied for just a few seconds before damaging the battery. Thus, never use the burst discharge rate as the design measure for your battery selection.

Overall though, the C-rating has proven to be somewhat unreliable across manufacturers as actual tests and measurements have shown. Therefore, I would consider the shown C-rating to be more of a marketing tactic by the manufacturer than a true performance indicator. Unless you actually conduct a performance test, I would take these claims with a grain of salt.

5 **Nominal voltage and cell count.** In the example, the cell count is 3 and the nominal voltage is 11.1 V. Please note that some manufacturers or distributors use classifications such as 3S1P to indicate the cell setup. "3S1P" simply refers to the number of cells and their circuitry. In this case, 3 cells are connected in series ("3S") with 1 parallel circuit ("1P").

Charging and Safety Tips

- Never charge a LiPo battery unsupervised or unattended for long periods of time.
- When charging, place LiPo batteries on a non-flammable surface (e.g., brick, concrete) and away from combustible materials (e.g., fuel, wood) or place them in a charging pouch or container available specifically for charging LiPos.
- Always use a charger that is specifically designed for charging LiPo batteries. Using the wrong charger can result in the destruction of the battery or charger, and cause a fire.

- For safety, charge LiPo batteries using the charger's "balance" mode to ensure that cells are not charged in excess of their maximum voltage. If using the normal charge mode, make sure to balance your batteries after the second or third regular charge to prevent overcharging of individual cells.
- Preferably charge your LiPo batteries at 1C (1 times the capacity of the battery) to ensure the longevity and safety of the battery. Although some manufacturers indicate that selected batteries can be charged at a higher rate (e.g., 2C-5C), it usually means that you will compromise the integrity and life of the battery over the long term.
- Never charge a LiPo battery when installed in the airplane. Always remove the battery from the airplane before charging.
- Always inspect LiPo batteries for damage or excessive puffiness, especially after a crash.
- Don't use LiPo batteries if they show clear signs of wear and damage.
- Routinely measure the IR of your batteries to assess if selected cells are degrading faster than other cells or if the total IR of the battery is starting to noticeably affect the performance of the battery. As a tip, label your batteries to indicate the purchase date and initial IR values per cell for reference.
- Always discard LiPo batteries following the manufacturer's recommendations.

Understanding Internal Resistance (IR)

Introduction

Internal Resistance, or IR for short, is an important measure that helps assess the **(1) health** and **(2) performance** of a LiPo battery over its lifecycle. By routinely checking IR values, you can safely determine when it's time to retire a LiPo battery.

In general, the change in IR values is a symptom of the aging process of a LiPo battery. The aging of a LiPo battery can be grouped into **(1) usage aging** and **(2) natural aging**. While usage aging accelerates the aging effect, natural aging is much slower and the result of a chemical process. In most cases, you will not notice the effects of natural aging. The reason is that most hobbyists retire their batteries long before that point due to usage (e.g., damage, performance issues of individual cells, charge/discharge cycle limit reached).

Because every charge and discharge cycle imposes stress on your battery, its performance gradually declines over time. This decline correlates with an increase in the IR value of the battery. More importantly, measuring the individual IR values for each cell gives you an even better understanding of your battery's health.

Measuring IR

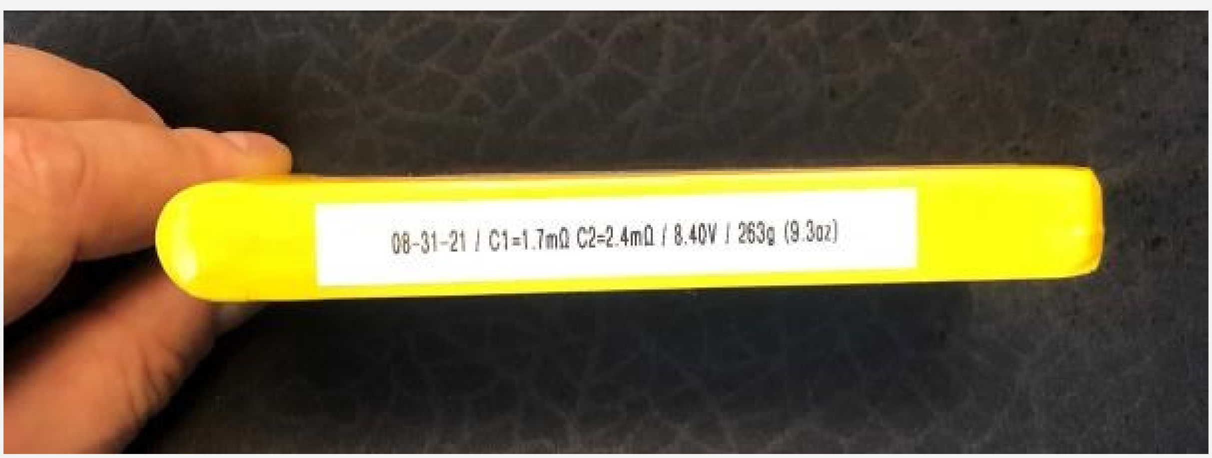
Before you measure your battery's IR, ensure consistent conditions. Consistent conditions allows you to minimize the potential for deviations in readings. These deviations can lead to incorrect interpretation of your battery's condition. This way, you can directly compare values of a new reading with the values from a previous (older) reading. The goal is to establish an IR value history over time for a given battery so you can anticipate when to retire the battery.

To actually measure IR, you can use a range of devices. In many cases, you can use your LiPo charger if it provides the option to display IR values per cell. Alternatively, you could get a dedicated device such as the 5-in-1 Tenergy battery meter. You can get it online at Amazon or other retailers. Just make sure that your device actually has the ability to measure IR. Some battery meters do not offer this feature.

Following are some general suggestions to consider before taking any measurements:

- Use the same equipment/device to measure IR values for each health check. Unless you have access to sophisticated and calibrated equipment, different measuring devices (by brand or product) will likely produce slightly different values. By using the same device for all your measurements, you will improve the comparability and interpretation of results.
- Make sure that the temperatures are the same for all your measurements. That is, take measurements at room temperature (e.g., 72 °F). Also, let your battery fully cool down to room temperature before taking a measurement.
- Measure the IR values after the battery is fully charged. The IR values of a partially discharged battery are higher when you start charging and then decline slightly as the battery approaches a full charge.
- If you charge your batteries at a higher rate (>1C), wait a while for the battery to cool down to room temperature after completing the charge. Because batteries warm up when charging at higher rates (>1C), the IR readings will be different for the same battery at room temperature.

TIP: Label your battery when you take your very first measurement, for example after you buy and fully charge the battery. This way you establish initial reference values that will help you gauge the IR changes over time. Below is an example of the labels that I place on all my LiPo batteries. In the example, you see a 2-cell LiPo. The information includes the **date** of the very first full charge, the **original IR values per cell** in milli Ohm (mΩ), the total **voltage** of the fully charged battery, and the battery **weight** in grams and ounces.



Interpreting IR Values

Interpreting IR values should focus on two things: (1) **Increase** in IR value **per** cell and (2) **differences** in IR value **across** cells over time. The first focus area is relevant for understanding the impact on performance. The second focus area indicates potential health (safety) concerns.

In general, as IR values increase over time, the battery experiences increasing energy loss due to increasing internal resistance. This is reflected in an increasing voltage drop, which in turn means decreasing maximum motor RPM. In addition, you might notice that your battery feels increasingly warmer after usage (assuming the same motor and propeller configuration).

The temperature increase is directly linked to the described energy loss because the battery is becoming less efficient in delivering the needed energy to the motor. Eventually, you will reach a point where the battery is no longer capable of enabling the flight performance you expect for your model. That's the point when it's time to retire your aged, but otherwise safe battery.

In contrast, premature retirement can have several reasons. One obvious reason is visible damage to a battery. Bending, cracking, or compression are clear signs that you should no longer use the battery—even if the IR values read out OK initially. You do not want to risk losing your model because there is no guarantee that the battery won't experience fatal failure during another flight.

A puffy battery, on the other hand, does not necessarily mean that the battery has gone bad. LiPo batteries do release gases during charge/discharge cycles that can be trapped in the shrink wrap, which causes puffing. As long as the IR values indicate a healthy battery and the puffing is not excessive, you can continue using the battery. However, you should monitor the puffing as a precaution in case it becomes severe enough to cause physical damage to the battery.

Example: Let's assume that after some time, I have gone through many charge/discharge cycles with one of my 3-cell batteries. To check its health, I take a sample reading and get the following values:

- Cell 1: 14.5 mΩ
- Cell 2: 29.3 mΩ
- Cell 3: 15.1 mΩ

I immediately notice that cell 2 shows a much higher IR value than cells 1 and 3. While the higher value of cell 2 does not necessary mean that the battery is no longer usable, it does tell me that cell 2 appears to degrade faster. I also notice during charging that cell 1 and 3 reach their target voltage (4.2 V) quicker. Also, the overall charge time of the battery is longer. In the past, it took about 40 minutes to fully charge the battery from 30% to 100% capacity—now it takes 60 minutes. I conclude that I should monitor this battery more closely and sample IR values in shorter intervals (e.g., after every third charge/discharge cycle). In addition, I decide to pay closer attention to the temperature of the battery after each flight. A warmer than usual battery could indicate that a cell is reaching its end of life.

While physical damage to the battery is easier to observe, identifying degrading individual cells requires measurement of the cells' IR. Typically, IR values for each cell are similar when you first purchase the battery. In this context, "similar" means within a similar magnitude. If you refer to the earlier example, my 2-cell battery shows a value of **1.7 mΩ for cell 1** and **2.4 mΩ for cell 2**.

Although these values are not exactly the same, they are within a similar range (1 to 5 mΩ). Usually, you can recognize a bad cell when its IR value degrades much faster than that of the other cells. The example illustrates why measuring individual cell values offers better insights into a battery's health. Moreover, it allows you to anticipate the potential retirement of a degrading battery.

Typical Initial IR values

One big question that many hobbyists have is: What are typical initial IR values for a new LiPo battery? In general, the lower the IR values, the more efficient a battery is.

There are many RC forums that have tackled this question and people have and continue to offer varying opinions. This topic is further complicated by the fact that there are no performance standards and guarantees that manufacturers of LiPo batteries have to meet. This means that hobbyists learn from trial and error which brands they like or don't like. In addition, the C-rating is often used as a marketing pitch by manufacturers and the actual capabilities of a battery can deviate significantly from the claimed C-rating on the packaging. Actual measurements have revealed that batteries with lower C-ratings can outperform batteries with higher C-ratings depending on brand. The sad thing is that even perceived reputable brands are not always delivering on their promise. At the end of the day, checking actual performance is the only way to distinguish true and false.

Fortunately, the RC community has developed empirical models to gauge expected IR values. One such model uses the following simple calculation:

Expected IR value per cell (at room temperate) = 12,000 / capacity of battery

Example: Battery capacity is 1,300 mAh

IR value per cell = 12,000 / 1,300 = 9.23 mΩ

Based on my personal experience, using a value of 12,000 seems a bit optimistic for many battery types that I use. The value assumes high-performance batteries. However, many hobbyists will likely choose cost-effective batteries for average flying, which generally do not deliver the high performance that this number assumes. Nevertheless, I do have a pair of 3-cell 1,300 mAh Turnigy Graphene batteries with an even lower IR value than the high-performance scenario that above calculation assumes. Therefore, I usually work with a range for my initial calculation before taking any measurements. For instance, you could use a range from 12,000 to 14,000 to get a ballpark value to work with. Then you can measure the cell values for comparison. Another approach is to collect the initial values of your preferred batteries and use that for reference instead.

If you are interested in the discussion of the above model, please refer to the following discussion thread on RC Groups (www.rcgroups.com):

- Description of the model: A simple LiPo performance tool - RC Groups
- Discussion board: LiPo "C" Ratings - A Replacement Overdue? - RC Groups

The above discussion board provides additional information, including links to a battery database that hobbyists have contributed using their own measurements. However, I must say that the database does not offer details about the age and condition of the batteries to put the uploaded values in context. So, I would take the data with a grain of salt. Nevertheless, it is a good source of information and offers additional data for your reference.

This is all from me for now. Stay safe and keep flying safely!

FIRE SAFETY

We're all aware of the tinder dry conditions in our area, particularly out at Popp's Field, certain to worsen over the summer. Toward that end, the Board purchased a couple of shovels to use as best we can to smother a fire, which may start from an impacted LiPo, an overtaxed ESC, fuel ignition, etc. There are now two with black handles to decrease visibility placed them on the north side of the 3rd Juniper tree east of the windsock, (nearly straight north from the east taxiway approach to the runway). He posted a sign that will hopefully keep them from wanting to go out and hike in the Badlands on their own, so to speak.

Also, remember the fire extinguisher in the club-house's large metal box, which we encourage all to remove and place by the green safety fence while flying and to replace it when closing the field. And, if reporting a fire, remember that Popp's GPS coordinates are listed inside the club-house on the south wall. In any emergency re-quiring first responders, dispatch someone out to the highway to face their vehicle toward Popp's and prepare to flag them down and lead them to the location.

So, when you're out in the sagebrush trying to find that airplane or pieces thereof, locate the shovels so you'll know where to go in case the need arises.

Bend Aero Modelers

Bend, Oregon | AMA District XI

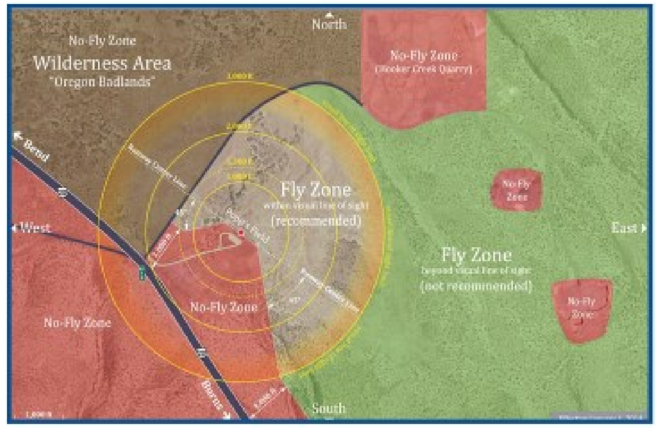
Field Safety Guidelines

A. GENERAL

1. All pilots shall have proof of current AMA membership prior to flying at BAM.
2. Visiting AMA pilots and new members of BAM shall receive a safety orientation by one of BAM's members prior to their first flight.
3. Pilots shall ensure flight operations in accordance with AMA's Safety Code and these Field Safety Guidelines at all times.
4. Pilots are responsible for the safe operation of their aircraft at all times.
5. Guests, spectators, children, and pets shall always be supervised by a BAM member inside the flying field (fenced area) and are encouraged to remain behind the pit tables.
6. Pilots shall always secure/restrain running or armed aircraft.
7. R/C cars and other surface vehicles are prohibited anywhere inside the flying field (fenced area) during active flight operation.
8. Smoking is prohibited anywhere inside the flying field (fenced area).
9. The consumption of alcoholic beverages and the use of controlled substances before or during flight is prohibited.

B. PRE-FLIGHT OPERATION

1. Pilots that use AM/FM radio equipment (50 MHz, 53 MHz, and 72 MHz) shall possess the appropriate frequency pin.
2. Pilots shall place their AMA card on the respective channel pin on the frequency board. This does not apply to pilots using 2.4 GHz transmitters.
3. Pilots shall not start/run their aircraft in the pit area.
4. For extended engine tuning and troubleshooting procedures (e.g., more than usually needed to start the engine), pilots shall use the marked areas designated for tune-ups, or break-in and troubleshooting.
5. Pilots shall never leave their aircraft unattended while the aircraft is running or armed, even if it is secured and restrained.



C. FLIGHT OPERATION

1. Pilots shall taxi aircraft only on the taxiways and runway, never in the pit area.
2. While flying, pilots must remain behind the safety fence.
3. Pilots shall verbally communicate their intentions during takeoffs, landings, low passes, touch-and-goes and emergencies.
4. Pilots shall always fly their aircraft north of the centerline of the runway and remain within the approved fly zones. (See Fly Zone Map for details.)
5. Only pilots and a supervised helper are permitted beyond the safety fence (e.g., to retrieve an aircraft).
6. Landing aircraft have the right of way. Dead-stick landings shall be called as such and given immediate right of way.
7. Aircraft shall not take off from the taxiways south of the safety fence.
8. Aircraft shall not land on the taxiways at any time.
9. Pilots shall call all maiden flights prior to the flight. All other aircraft shall be grounded until the maiden flight has been completed.

February 25, 2016 / Revision C

POPP'S FIELD SAFETY GUIDELINES

Providing and enforcing a safe flying environment is essential to BAM's success. Your Executive Committee discussed our guidelines and noted that it would be helpful to have the information posted conspicuously at the field. This serves two purposes. First, it is useful in providing orientation to new potential members and guests. A second use is for each of us to refer to it periodically to refresh our memories and follow the guidelines as intended, enforcing where required.

Accordingly, we configured our guidelines as above and had it printed at a local sign shop. It will be placed on the north side of the sign bracket that protrudes from the clubhouse's northeast corner, so check it out while you're at the field. AND — get out there and take advantage of our beautiful field. Watch the video Joeie Canaday produced that Waldemar placed on our website and it'll beckon you to get fired up and drill some holes in the air with your planes!