Job Hazard Analysis

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| **University of Washington:** UW Seattle | | **Department:** Aeronautics and Astronautics | | |
| **Activity or Process:** LiPo Battery Operations | | **Building/Room:** AERB 117 | | |
| **Job Title:** Student Researcher | | **Supervisor:** Christopher Lum, Ph.D | | |
| **Prepared By:** Nicholas Price | | **Date: 1/8/2019** | | |
| ***This document is the certification of hazard assessment for PPE for the workplace.*** | | | | |
| **TASKS/STEPS** | **HAZARDS** | **CONTROLS (SAFEGUARDS)** | | **PHOTO** |
| 1 Charging   1. Connect battery to balance charger via xt60 connection and multi-pin connector. 2. Navigate the menu of the charger to the option “LiPo Balance Chg”. This ensures the charger uses the pin connection to balance the charge in each cell. 3. Use short press of “enter” button to cycle through settings of “Amps” and “Cells”. 2.5 – 4.0 A should be a safe charge rate for our 3S batteries. 4. Use long press of “enter” to start the charge cycle. | * Fire: Charging at too high a rate, or not charging each cell to an equal voltage (a balanced charge) could cause a cell to “pop”. Exposure of the chemical cell to oxygen or excess heat, alongside the pressure release, can lead to a stream of flame ejected from the battery. * Swelling: Symptom of too high a charge rate for the state of the battery. This can also be symptomatic of a damaged battery if charge rate is reasonable but swelling results regardless. * Smoke/Hot Gases: Generally attached to the case of fire. Battery could pop without flame, but will likely still release toxic fumes. * Overheating when charging or discharging: Symptomatic of too high a charge rate. A warm battery during charge/discharge cycle is common, but use best discretion to determine an unsafe situation. | * Track actions on battery log (i.e. start/stop time when charging, voltage, etc.) * ABC fire extinguisher * Charging station is fire resistant and not in proximity to combustible materials (Batt Box) * Attendant present at all times during charging process * Only manufacture recommended charger is used * Set aside cooling time after battery has completed charge * Good quality balance chargers should have a built-in fan to prevent overheating failure of the electronics in the charger. | | Fireproof Battery Charging Box with Balance Charger/Discharger – AERB 117 |
| 2. Storage   1. Connect battery to balance charger via xt60 connection and multi-pin connector. 2. Navigate the menu of the charger to the option “LiPo Storage”. This ensures the charger uses the pin connection to balance the charge in each cell. 3. Use short press of “enter” button to cycle through settings of “Amps” and “Cells”. 2.0 – 2.5 A should be a safe discharge rate for our 3S batteries. Generally, just discharge at a lower rate than you charge the battery at. 4. Use long press of “enter” to start the discharge cycle. | * Overheating: Generally caused by leaving the battery in a poorly ventilated area, under direct sunlight, or near a heat source. In an extreme case this can lead to a battery fire. The more likely outcome is to shorten the lifespan or long term durability of the battery. * Fire: LiPo batteries purchased from reputable sources should not catch fire without some external accelerant introduced while in storage. Fire danger in storage is more attributable to damaged, unstable batteries not identified before being put in storage. | * ABC fire extinguisher * Stored in well ventilated area, out of direct sunlight * Kept in designated fireproof LiPo bags in fire resistant cabinet * Use the “LiPo Storage” setting on the balance charger/discharger to set batteries at a 50% storage charge. * Store away from combustible materials * Visually inspect batteries in storage at least weekly. | | LiPo Storage Container - AERB 117    ABC Fire Extinguisher – AERB 117 |
| 3 Disposal   1. Connect battery to balance charger via xt60 connection and multi-pin connector. 2. Navigate the menu of the charger to the option “LiPo Discharge”. This ensures the charger uses the pin connection to balance the charge in each cell during the discharge cycle. 3. Use short press of “enter” button to cycle through settings of “Amps” and “Cells”. 2.0 – 2.5 A should be a safe discharge rate for our 3S batteries. Our balance charger will discharge at a lower rate as the 3S battery nears its baseline voltage of ~9.6V; no cause for concern. If the battery is in poor condition, use best discretion to determine a low discharge rate, too high a rate of discharge could result in battery failure in extreme cases. 4. Use long press of “enter” to start the discharge cycle. | * Fire: Greatest fire danger is during the discharge cycle for the battery. Batteries reach the end of their lifespan in a variety of conditions. Batteries in bad physical condition that swell during the discharge could “pop” and create fire as described in the charging section. * Swelling: Common for old batteries to swell at low charge. Creates the greatest danger for battery packs that have physical damage that could cause them to rupture under internal pressure. * Overheating: Much like the charge cycle, discharging at a high rate could overheat the battery. Again, this is more problematic for batteries in the worst condition. Old batteries that simply have difficulty holding a charge should be low risk. * Ruptured Cells: As described above, physical damage could rupture, exposing the chemical cell to oxygen and creating fire. | * Discharge battery pack using the “LiPo Discharge” setting on balance charger/discharger. Only discharge in the fireproof Battery Box pictured above. * Check battery voltage to ensure battery is fully discharged. Baseline voltage should be ~3.2V/Cell. * Dispose of damaged batteries in e.Media bin on campus (if less than 5lbs). Otherwise, complete an Online Chemical Waste Collection Request. * Batteries to be disposed of should be placed in the designated “Dead Batteries” metal box in AERB 117 | | Dead Batteries Box – AERB 117 |
| 4 Transportation and Packaging | * Overheating: The risk of overheating during transportation is more linked to negligence. Batteries could be accidentally left in a vehicle in between the lab and the test site. * Physical damage leading to ruptured cells: Another unlikely danger that would arise from the batteries being jostled in transit. | * Transport is fireproof container * Transport with all plugs and connectors covered * Transported batteries are not left in hot areas; in direct sunlight, or next to a space heater in the MFOC * Visually inspect batteries after transportation to verify integrity * Travel with ABC fire extinguisher * Transport in individual fireproof LiPo bags * Separate charged/unused batteries from discharged batteries when going between lab and test site | | A Properly Packaged LiPo Battery Pack: In a fireproof bag, XT-60 connecter covered. |
| 5 General battery handling | * Corrosion: A pretty common occurrence with our batteries, usually forms on the connector leads of the XT60. Can lead to decreased battery performance, or a loss of power, particularly hazardous during flight of a UAV. * Short occurs from contact with metal jewelry: Short circuiting a LiPo battery is the most common critical event to have occurred in our lab. The typical situation is that a battery connector is being worked on and the leads are accidentally shorted with a wire or other piece of metal the researcher isn’t paying attention to. Past events have resulted in a melted XT60 connector, fumes, and some smoke. The heat created by the high current can lead to a LiPo fire. Short circuited batteries should be disposed of. * Using a battery above or below recommended use window (i.e. 3.0V/cell to 4.2V/cell) * Improper soldering work on the connector could lead to poor connection, or exposed wire. | * Hygiene: wash hands before & after battery handling * Safety glasses * Remove wristwatches, bracelets and rings * Look for corrosion in the connector leads, replace connector if corrosion is found. * Always seal exposed wire in electrical tape as a temporary fix. Permanently fix with heat shrink when/if new soldering work is finished. * Use handheld battery checker to confirm nominal battery charge (fully charged, cells balanced) before use * Always inventory LiPo batteries in the component tracker * LiPo batteries should ideally be limited to 300 charge cycles. It’s commonly understood that hobby-grade LiPos begin to lose performance past this point. * Purchase batteries from reputable sources. This generally means not buying used LiPos, and try to buy new from Hobby RC suppliers which post positive user reviews of the batteries. | | Handheld Battery Checker |
| 6 In-Flight LiPo Use | * Loss of Power: A connection issue mid-flight could lead to a loss of pilot/autopilot control of the airframe * High draw scenarios: Aircraft can draw high amperages during power-intensive maneuvers, typically takeoff and climb out. An especially high draw on the battery can lead to overheating and possibly fire. * Impact Damage: A crash scenario which sees the aircraft nose dive could result in physical damage/rupturing of the cell packaging, possibly resulting in fire. * Overheating: Similar to the transportation scenario, batteries may be forgotten in the aircraft after recovery. On a hot day, this could lead to an overheated battery. | * As you would expect, we have little direct control of the battery once in the air. This makes proper ground maintenance and control of the LiPo batteries essential. * The Ardupilot control software we fly on our flight controller uses signals from a “power module”, installed between the battery and the ESC, to monitor battery voltage, current draw, and estimate capacity used. Researchers can monitor this telemetry in the Mission Planner ground control GUI and make recommendations to the Pilot in Command on the status of the battery during the flight. * Ardupilot also uses a failsafe mode to cut most power to the aircraft when it detects a voltage across the battery approximately below 9.3 – 9.9 V. This performs multiple helpful controls. For one, it prevents the battery being used at voltages below 3.2V/Cell. It can also act as an indirect failsafe on high currents. LiPos have an interesting behavior where periods of high current draw will temporarily reduce voltage across the cells. Ergo, a voltage failsafe on takeoff may indicate too high a current draw from the motor/other systems. In nominal performance from the battery, the voltage should not decrease to the point of triggering a failsafe during takeoff, thus a failsafe can be an indicator of a battery nearing the end of its lifespan. * ABC Fire Extinguisher * In the event of a LiPo fire as a result of a UAV crash, use best discretion when determining if it is safe to put out the fire yourself. Always call 911 first. | |  |
| 7 Damaged battery | * Fire: A LiPo cell exposed to oxygen or overheated will catch fire. This means that the integrity of the cell packaging is paramount to fire safety where LiPos are concerned. A LiPo fire is often accompanied by the discharge of high pressure gasses leading to a stream of flame/hot gases. * Swelling: As mentioned before, a battery near the end of its lifespan will swell under low charge. This is an indication of gas build-up in the chemical cell. This is generally not dangerous by itself, but contributes to more dangerous situations when flame is involved. * Buckled Battery Pack/Physical Damage: Common occurrence as a result of an aircraft crash. | * LiPo chemical cells exposed to air (i.e. a ruptured cell) will tend to combust, ABC or BC fire extinguisher is necessary * Gloves * Fireproof container (Batt Box) * Safety glasses * Eyewash station adjacent to soldering table, in case of chemical irritation of eyes. * Suspect batteries can be checked by applying a proper charging cycle to full charge, waiting one hour, then checking the remaining charge. Significant depreciation from 4.2V/cell signals a damaged battery. * Dispose of damaged batteries in e.Media bin on campus (if less than 5lbs). Otherwise, complete an Online Chemical Waste Collection Request. * Label fireproof LiPo bag, “Danger : Bad Battery” * Note battery number designation in the component tracker as Damaged/Disposed | | Damaged Battery (ruptured packaging, swelling)    Damaged Battery (ruptured packaging, swelling, pack buckled from impact, exposed connector lead) |
| **Required Training** | | **Required PPE** | | |
| EH&S Fire Extinguisher Training - Online  Electric Safety Basic - Online  Click to add required training.  Click to add required training. | | Safety glasses  ABC Fire Extinguisher  Click to add hearing protection.  Click to add respiratory protection. | | |
| ***I have read and understand the contents of the job hazard analysis and the controls required to mitigate the risks from the idenitified hazards*** | | | | |
| **Name** | | | **Date** | |
| Nicholas Price | | | 1/8/2019 | |
| Josh Lee | | | 3/11/2019 | |
| Rostyk Svitelskyi | | | 3/14/2019 | |
| Helen Kuni | | | 3/15/2019 | |
| Mozes Jacobs | | | 3/30/2019 | |
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| Conner Smith | | | 4/30/2019 | |
| Eli Sitchin | | | 6/17/2019 | |
| Liam Mortell | | | 6/25/2019 | |
| Chris Hayner | | | 6/25/2019 | |
| Parker Mayhew | | | 6/27/2019 | |
| Rori Fortmann | | | 6/28/2019 | |
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