Lead-Acid Battery Pack Safety Procedure

9/3/2014
Rev.0

1.0 PURPOSE AND SCOPE

This procedure describes the safety requirements that apply to lead-acid battery packs under normal and emergency conditions. All WHOI personnel that design, use, store, and dispose lead-acid battery packs (including WHOI research equipment that contains lead-acid battery packs) must review and follow this procedure and complete WHOI's Battery Pack Online Safety Training.

2.0 LEAD-ACID BATTERY HAZARDS

- Lead-acid batteries produce hydrogen gas, especially during charging. Hydrogen is explosive at concentrations between approximately 4% and 75% by volume with air.
- Lead-acid batteries contain sulfuric acid, which is corrosive and can burn and damage the skin and other body tissues.
- Lead is toxic to human health and is considered an environmental pollutant.
- Lead-acid batteries contain a considerable amount of energy, which can be a source of high electrical current and a severe electrical shock in the event of a short circuit.

3.0 HYDROGEN GAS GENERATION FROM LEAD-ACID BATTERIES

Battery manufactures report that hydrogen and oxygen gas can be generated during charging and operation of lead-acid batteries and that the rate of hydrogen gas generation increases as the charging voltage and battery temperature increases. Hydrogen gas is explosive at concentrations between approximately 4% and 75% by volume in air at standard temperature and pressure.

If lead-acid battery packs are going to be used in air-tight or water-tight enclosures, the potential for hydrogen gas generation must be evaluated and safely controlled. The following lessons learned were identified during the investigation of an OOI/CGSN mooring explosion and should be considered during design and use of lead-acid battery packs in enclosed equipment and instruments:

- Reduce the potential for an explosive atmosphere to be generated within the battery pack compartment with mechanical ventilation and/or other engineered control methods.
- Eliminate ignition sources before an explosive gas concentration is created. For example, monitor the battery compartment for an explosive gas concentration and interlock the power supply to automatically shut off before the lower explosive limit (LEL) is reached. Flammable gas sensors are available for this purpose.
- Implement a method to remotely and rapidly identify potentially explosive conditions (e.g., flammable gas sensor) and mitigate the potential explosion or fire hazard (e.g., eliminate ignition sources, reduce flammable gas concentration below the LEL, etc.).

- Develop procedural steps to safely mitigate and recover a mooring that may be explosive. For example, an inert gas could be used to purge the battery compartment before it is opened.
- Coordinate with the battery pack manufacturers to design safer battery packs.
- All WHOI personnel that design and handle battery packs must complete WHOI's battery pack safety online training: http://ehstraining.whoi.edu/private/BatteryPackSafety.pdf.
- Review previous incidents for lessons learned that may be applicable to this incident, including the transponder sphere explosion that was caused by hydrogen gas generated from an alkaline battery pack.

4.0 BATTERY PACK DESIGN, FABRICATION AND HANDLING

To increase the safety margin and decrease the failure rate of battery packs, the hazard analysis process needs be conducted during the design phase of battery packs. WHOI's Lithium Battery Safety Guideline provides more information about the hazard analysis process.

- Before designing battery packs, review the battery manufacturer's technical specifications for the same type of cells that will be used in the battery packs.
- Before designing enclosures/compartments for battery packs determine the requirements for cell venting, heat transfer, and ventilation. Minimum ventilation rates need to be determined for the worst case conditions expected over the life of the battery pack and consider the following factors: maximum charge voltage, maximum cell temperature, and maximum rate of hydrogen gas generation for the charging mode (e.g., constant voltage charging, constant current charging, etc).
- Battery use, charging, and charging locations must be adequately ventilated and safeguarded from ignition sources.
- Choose batteries with the lowest power output needed to meet the application requirements.
- Use the same battery type with equal capacity throughout the battery pack. Mixing different sizes, capacities, and chemistries can cause hot and leaking cells.
- The battery pack design should minimize the chance of shorted cells (i.e., battery's positive and negative terminals are directly connected with a conductor), which causes excessive heat and is a fire hazard. To avoid a possible short, ensure the correct polarity when charging a secondary cell.
- Choose the appropriate charger and charging program for battery type. Check manufacturer's specifications on recommended voltage thresholds. Note: some battery manufacturers discourage the use of constant current charging.
- Over-charging a lead-acid battery can produce hydrogen-sulfide, which is colorless, very poisonous, flammable, and has the odor of rotten eggs.
- Ensure an emergency shower is immediately available when working with sulfuric acid. Wear acid-resistant personal protective equipment (safety glasses, gloves, etc) when handling sulfuric acid. Pour concentrated acid slowly into water – do not add water to acid. Replenish electrolyte fluid with distilled water.

5.0 EMERGENCY PROCEDURES

5.1 HYDROGEN GAS IN ENCLOSED SPACE

If hydrogen gas may have leaked from a battery pack and has accumulated in an enclosed space, the hydrogen gas must be safely vented and protected from ignition sources. As applicable and if safe to perform, the following steps should be considered for safely mitigating this condition:

- Do not inspect the device or vent the hydrogen gas near any potential ignition sources.
- Isolate the device/instrument from any external and internal electrical or signal connections.
- If safe to perform, vent the device in a well-ventilated location that is safely away from potential ignition sources.
- If the hydrogen gas cannot be safely vented, remote dismantlement or remote destruction of the device may need to be considered.
- Note: these steps should only be performed by personnel that are knowledgeable of the device/instrument in question and understand the associated hazards.

5.2 LEAKING CELLS

Damaged cells can leak electrolyte, which consists of a sulfuric acid solution (typically at a 35% concentration). Sulfuric acid is a corrosive that can damage the skin and eyes.

1. Don proper personnel protective equipment (acid-resistant gloves, eye/face protection, lab coat) before attempting to deal with leaking lead-acid batteries. Ensure that emergency wash water is immediately available. If your skin or eyes are exposed to the battery electrolyte, immediately rinse affected body parts with water and seek immediate medical attention for injuries.
2. Spilled electrolyte should be neutralized before being cleaned up. Spilled electrolyte from lead-acid batteries can be neutralized with an approved acid neutralizer, such as Spill-X-A Acid Neutralizer that is available in the green wall-mounted spill kits or from the EH&S office.
3. Spill cleanup materials should be collected in a suitable collection container that is properly labeled. The leads on the damaged cells should be covered and the batteries marked with a warning sign (e.g., damaged cells - do not touch or move). Contact EH&S for assistance with disposal of damaged lead-acid batteries (x3347 or wastepickup@whoi.edu).

5.3 LEAD-ACID BATTERY FIRES AND EXPLOSIONS

In the event of any fire (including a lead-acid battery fire), activate the nearest fire alarm and call x2911 (508-289-2911 from cell phone) to report the fire. Only trained and properly equipped emergency responders should attempt to fight lead-acid battery fires. An explosion of a lead-acid battery can rapidly and forcefully release battery debris and sulfuric acid.

6.0 WASTE MANAGEMENT AND TRANSPORTATION

- Lead-acid batteries that are spent or otherwise considered waste, cannot be disposed as regular trash and must be recycled.
- Batteries that are not clearly identified by manufacturer must be clearly labeled by the generator as “Lead-Acid Batteries”.
- All exposed terminals must be taped or enclosed to prevent short circuiting.
- All lead-acid batteries with removable electrolyte caps must be kept upright to prevent leakage.
- Do not mix incompatible batteries in the collection container and replace the container lid.
- For assistance contact wastepickup@whoi.edu or x3347.
- Batteries should be transported in a manner that prevents short circuit or other abusive conditions. Contact the WHOI Distribution Manager for questions about properly shipping batteries.