Issue Date or Doc #	Safe Work Practice (SWP) Lithium-Ion Battery Testing	
ENG-SAF-SWP-002.00		
Authoring Dept: Faculty of Engineering	Battery testing is done on battery cells, modules, or packs to determine the state, health, and performance of the battery. Certain parameters are measured and recorded during testing, which provides useful information about the battery. Battery testing could also be useful for predicting the life cycle of the battery. This SWP is intended for activities where battery testing is a peripheral component rather than the primary purpose. It is recognized that while this information may be useful in battery research, it may not be adequate or applicable.	

TRAINING REQUIRED

This SWP must be reviewed and understood before proceeding. This document is meant to supplement other information including but not limited to training, hazard and risk assessments, procedures, standards, and manufacturer information. The manufacturer's instructions should be reviewed before using equipment and followed. Do not proceed unless you have received training on equipment use, reviewed manufacturer instructions, and have been approved to proceed by an authorized person or group. Follow standard housekeeping and pre-use inspection practices.

REPORT ANY DEFECTS OR DEFICIENCIES IMMEDIATELY TO YOUR SUPERVISOR.

1. Potential Hazards and Personal Protective Equipment (PPE) Requirements

- Chemical hazards: Venting/Leakage. Chemical-resistant latex disposable gloves and safety goggles should be worn to protect the skin and eyes against escaped fluids from the battery.
- Mechanical hazards: Mechanical hazard my occur if the battery is dropped, cut into, or distorted due to mechanical force applied on the battery. This could result in flying objects or internal faults, which may lead to serious injuries, particularly when dealing with battery modules/packs. Safety gloves (Cut-resistant) and boots (standard green triangle) should be worn to protect feet. Cut-resistant safety gloves are recommended for low-voltage battery testing.
- Electrical hazards: Hazards under this category includes electric shock, arc flash, short-circuiting leading to overheating or fire hazards. Safety gloves and goggles should be worn to protect from electric shock and very bright flashes. For operating voltages above 60 VDC (Volts Direct Current), the full arc flash protective kit including high voltage electrical gloves, arc-rated coverall, balaclava, helmet, face shield, safety boots and glasses, should be worn.
- Fire Hazards: Overheating, thermal runaway, explosions are all potential battery hazards in this category. Hence testing should be isolated from common areas.

COMMON HAZARDS

						
Toxic Fluids	**Corrosive Material**	**Flammable**	**Explosion**	**Electric Shock**	**Arc Flash**	**Flying Objects**

 **Hot Surface**	 **Weight Dropping**					

RECOMMENDED PPE						
 **Safety Goggles** Required	 **Gloves** Required	 **Safety Boots** Required	 **Other Body Protection** Task Dependent	 **Face Shield** Task Dependent		

2. Pre-Operational Safety Items

- Review the technical data sheet & safety data sheet from the battery manufacturer.
- Do a visual inspection of the battery cells/modules/pack, check for leakages, dents on the battery, swelling/bulging of the cell. If any of these are found, isolate affected cells (in a fume hood if available).
- Take the Open Circuit Voltage (OCV) of the cell/module/pack using a multimeter to determine the state of charge of the battery. Compare values to the range specified in the datasheet.
- Measure the Internal Resistance (IR) and compare with the datasheet.
- Insulation Resistance test is necessary for modules/pack level testing. To determine the minimum insulation resistance required see the procedure for insulation resistance calculations.
- Attach temperature sensor to the battery. Position on the sides/top/bottom of the cell. Use multiple sensors (labeled) at strategic positions for modules and packs.
- Verify the need for Battery Management System (BMS), mid-module/mid-pack connector etc. **For battery modules/packs, a BMS is necessary.** If the whole system voltage is more than 60 VDC, the unit must be grouped into groups of not more than 60 VDC, and a mid-connector is needed.

If BMS is present, subsequent steps should be done in the order in which they are listed:

- Connect battery to BMS,
- Connect Temperature sensor(s),
- Program BMS; set the safety limits for voltage, current, and temperature (including time limits if necessary),
- Connect Current collector to power supply,
- Connect Voltage connector,
- Connect mid-module connector,
- Connect mid-pack connector last.

If no BMS is present:

- Connect Temperature sensor,
- Connect Current connector,
- Connect Voltage connector.

Note: It is important to have control of your power supply unit so that testing can be stopped when necessary.

3. Operational Safety Items

- The ambient temperature must be below 25 ± 5°C at the beginning of battery testing as stated by UL 9540 (2020).
- Standards including UL and NFPA recommend that the operating temperature of a battery remain within the range specified by the manufacturer. If a manufacturer range cannot be determined, a range of -20°C to 60°C for lithium-ion batteries is the typical standard used.
- Safety limits and protection alarms for current (to within ± 1 A of the operational current), voltage (to within ± 0.5 V of the operational voltage) and temperature (following the safe operational range) must be in place during testing.
- Run script/start test.
- Battery should be repositioned to about 40% state of charge before storage.

4. Post-Operational Safety Items

Post testing, battery should be disconnected in this order, using the necessary PPE.

- Disconnect mid-pack connector,
- Disconnect mid module connector,
- Disconnect Voltage connector,
- Disconnect current connector,
- Disconnect BMS from battery,
- Remove temperature sensors,
- Isolate leads using insulation tape,
- Package for storage/other use,
- Store battery on low racks or closer to floor level with larger cells below and smaller cells stacked up, if necessary, to prevent from dropping.