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### **Safe Working Practices:** **SWP- 43 Lithium-Ion Batteries and Associated Hazards**

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Before doing any type of work you must carry out an assessment of the task to be undertaken. Consider equipment, the task, Personal Protective Equipment, work area, environment and tooling for being able to complete the task safely. Consult your team leader if you are not satisfied the job can be carried out in a safe manner.

#### **General**

Battery construction consists of several modules which contain several small cells. These modules are removable and interchangeable to aid maintenance. The charging and general applications of the batteries are controlled by the Battery Management System (BMS) which is linked to each of the modules. The BMS measures many safety aspects including voltage and temperature.

The batteries are robust and considered more resilient than lead acid. The main risk is fire or thermal runaway, although considered low probability when handled and used correctly. Special considerations are required to ensure defective batteries are handled and stored appropriately. Procedures for dealing with batteries involved in fire are required to ensure a safe resolution can be had in case of emergency.

#### **General Precautions**

- 1.0 Avoid short circuits.
- 1.1 Avoid reverse polarity (incorrect connections) during installation.
- 1.2 Keep the battery dry.
- 1.3 Do not expose the battery to strong oxidising agents, acids, peroxide etc.
- 1.4 Do not damage or remove the battery cover.
- 1.5 Keep away from naked flames, hot surfaces or sources of ignition.
- 1.6 Do not solder directly onto the battery.
- 1.7 Do not damage or deform the battery. Protect the poles from mechanical impact.
- 1.8 Do not wear jewellery made from conductive material whilst handling batteries.
- 1.9 It is imperative that the battery does not reach a state of deep discharge.

If the battery is not fitted to any equipment then the following considerations must be adhered to whilst storing:

- 2.0 Do not store the batteries with metal products, water, strong acid or strong oxidising agents.
- 2.1 Store indoors, in a ventilated container or under shelter. The environment temperature should remain between -20 and +35 degrees, humidity 45-85%, and dry always. Optimum temperature is just below 20 degrees Celsius.

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- 2.2 Avoid direct sunlight, high temperatures and high humidity.
- 2.3 Keep in closed original container to prevent short circuit.
- 2.4 Shipments containing Lithium-Ion Batteries must be identified as ADR Class 9A – Miscellaneous – Lithium Batteries.



### Working with Batteries

When replacing modules / BMS or working on the batteries the following is to be adhered to:

- 3.0 Only authorised and qualified personnel are to work on Lithium-Ion Battery systems.
- 3.1 Only use tools from the authorised tool kit (Part Number GB1PAL0001927). These are specialist rated tools with the correct insulated protection required when working on Lithium Ion batteries.
- 3.2 Always ensure the BMS is OFF. If the light is flashing intermittently then the unit is still on. Wait for a short time to ensure that the unit is off.
- 3.3 Ensure that you are not wearing any jewellery made of a conductive material.
- 3.4 Always insulate cables as soon as disconnected.
- 3.5 Always replace the insulated bolts to the terminal as soon as disconnected, this protects the terminals and reduces the risk of shorting on the modules. Terminals should always be covered to prevent short circuiting.
- 3.6 Always use a magnetic bowl to place all nuts and bolts into to avoid dropping them onto the battery / equipment, reducing the risk of a short circuit and damage.
- 3.7 When tightening any nuts, bolts and screws always ensure that the correct torque settings are used to avoid damage to the battery units.
- 3.8 The modules come in three sizes and two types (right handed and left handed). The type annotates the polarity so it is imperative that you are aware of which module is which. A battery may consist of a number of each module type, both LH and RH. It is critical that when replacing modules that you ensure it is like for like (R/H for R/H, L/H for L/H). These are identifiable by part number shown on the module.
- 3.9 Gloves, Apron and Goggles must be worn whenever vermiculite is being handled. Although vermiculite is non-toxic, this level of PPE is required for comfort.

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### Storing and Charging of Equipment with Li-Ion Batteries

Minimum amounts of batteries are stored at any one time and a process in place for ensuring batteries are rotated to ensure no battery or module is left in storage for unnecessary lengths of time. The following applies:

- 4.0 Modules are received from supplier with approximately 30% charge. Modules are stored and remain in this state until picked and delivered.
- 4.1 Always remove the isolator when parked up.
- 4.2 A charging regime is not required as standard. But where necessary, deep discharge and overcharging are avoided.
- 4.3 Charging should only take place in the designated charging area. Charging is prohibited in Lithium-Ion bulk storage areas. Charging areas should be in a well-ventilated area and away from bulk storage. Charging areas should be serviced by an appropriate number of AVD Extinguishers.
- 4.4 Defective batteries should never be stored with undamaged / new batteries.
- 4.5 Metal shelving should not be used, especially for larger batteries, to reduce the likelihood of short circuiting.

### First Aid

The following first aid actions are only necessary if there is exposure to the interior battery components. Undamaged closed cells do not offer a danger to health.

- 5.0 In the case of inhalation, move to area of fresh air then seek medical advice.
- 5.1 Upon contact with skin, wash off immediately with plenty of clean water. Remove all contaminated clothing. If irritation persists, seek medical advice.
- 5.2 Upon contact with eyes rinse immediately with clean water, including under eyelids for at least 15 minutes. Seek medical treatment from an eye specialist.
- 5.3 If ingested, drink plenty of water and seek medical advice immediately.

### In Case of Fire / Avoiding Thermal Runaway

Fire involving Lithium-Ion batteries differ from those normally associated with batteries and should be treated differently. Due to the construction of the battery, any initial shorting that results in fire would be confined to the few cells that are directly affected. This means that, although intense, the fire would be quite small. As the cells burn, they generate high heat, which would then cause adjacent cells to ignite. This is called Thermal Runaway. The quantity of lithium in the batteries does not constitute an immediate hazard from water as it is imbedded in compounds. The fire will be very intense and priority should be given to, if possible, removing the unit outdoors to a safe area. The chance of extinguishing a fire without the specialist training and equipment is very unlikely. Priority must be given to putting out the flames and moving the equipment to a safe area outside before thermal runaway can take hold. **Thermal runaway can be avoided or delayed by prolonged cooling, achieved by applying copious amounts of water directly onto the affected area for as long as required prior to the arrival of the emergency services.**

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- 6.0 In the case of a fire raise the alarm immediately.
- 6.1 If possible, move the battery outdoors.
- 6.2 It may be possible to initially extinguish the fire and then move the equipment to a better location as described in 6.1.
- 6.3 Call Emergency Services. Extinguishing the fire requires specialist equipment and knowledge.

A copious amount of water is needed as priority is to cool the battery down, thus stopping the thermal runaway.

**If involved in fire, toxic fumes including Hydrogen-Fluoride, Ethane, Methane, Carbon Monoxide and Carbon Dioxide are given off. If damp, fumes may include Hydro-Fluoric Acid. Inhalation of any fumes should be avoided at all costs.**

#### **Transport Obligations under ADR (Dangerous Goods By Road) Legislation.**

- 7.0 Lithium-Ion batteries are subject to ADR regulations. Risk of incident is deemed low under normal circumstances.
- 7.1 ADR stipulates packaging, labelling and carriage requirements of all hazardous goods, and can include limitations on quantities. In many cases, specialist licensing is required to move the items. The threshold for Lithium-Ion modules is ADR score 1000. With a safety margin applied, this is represented by 333kg of Lithium-Ion batteries.
- 7.2 Vehicles can carry less than 333kg without a special license, providing they are packaged correctly. This includes TMHUK Technician Service Vans.

#### **Returns of Defective Batteries / Modules**

Lithium-Ion batteries and modules are delivered in bespoke packaging that adheres to ADR (Transportation of Dangerous Goods) Legislation. A paper checklist is included which enables you to ascertain the viability of returning the module to the supplier and the condition under ADR for the return of the module / battery. Upon completion of this check sheet, a module can be deemed to be either **Critical** or **Non-Critical**.

#### **Defective Non-Critical Modules**

- 8.0 Non-Critical modules are to be packed and returned in the same format and packaging that the new module arrived in.
- 8.1 Ensure that the module is segregated from other items through placement in the vermiculite found within the packaging, this is an important step.
- 8.2 Ensure the completed checklist is placed inside and all labels are visible. The module can now be returned through the normal TMHUK returns process.

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- 8.3 For warranty returns, **ensure the orange warranty return label is kept with all other documentation** and visible from the exterior of the package. The label should not, under any circumstances, be placed on the module itself or inside the box.
- 8.4 **All Non-Critical Modules are to be returned to Leicester Parts.** When arriving at Leicester, non-critical batteries are sifted from waste returns, isolated and stored only in designated areas and in accordance with the following protocols:
- Fire resistant.
  - Dry.
  - Well ventilated.
  - Temperature kept between -20 and +35 degrees Celsius (optimum just below 20).
  - Humidity kept between 45-85%.
  - Away from other buildings.
  - Well signed.
  - Away from other flammable materials.
  - Subject to good housekeeping and 5S standards.
  - AVD Extinguishers placed in appropriate areas and proximity.
  - Never stored with undamaged or new batteries.
  - If boxes containing Vermiculite must be opened, Gloves, Apron and Goggles must be worn. Although vermiculite is non-toxic, this level of PPE is required for comfort.

**Water exposure must be avoided at all costs to ensure environmental protections measures are being maintained.**

- 8.5 Defective batteries stored at Leicester are collected and disposed of only by approved contractors. Arranging the collection of defective batteries is the responsibility of the Parts Warehouse Manager and should be done at least every 14 days. This can be reduced at the discretion of Leicester Parts.

#### **Defective Critical Modules**

- 9.0 A battery or module that has been identified as critical should be removed to a safe, external location to await disposal. This should only be done if safe to do so.
- 9.1 Battery Care should be informed and will confirm collection within 4 hours.
- 9.2 Critical modules are transported directly to Veolia for disposal. This can only be done by specialist contractors. **Under no circumstances should this be done by TMHUK personnel or in a TMHUK vehicle.**
- 9.2 Special containment and packaging are required for this task which can be fulfilled by the Battery Care contractor.

# Safe Working Practices:

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### Lithium Ion Battery/Module Fault

