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Revision: 2.0

Reviewer: Geoff Nudge

Safety Plan

ECE 492 - Spring 2016

Abstract

This document outlines the safety plans for maintenance and operation of LFEV systems. The appropriate section of this document must be present and read before work begins on any component listed in this document.

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General Requirements

Participants

The guidelines laid out in this document apply to all students involved with the Lafayette Formula Electric Vehicle (LFEV) project. All students must agree to and comply with all restrictions described in this document. Students may not grant access to any system listed in this document to any person not directly involved in the LFEV project.

Documentation

This safety plan and all included test procedures will be archived on the course website. The hardcopy found with the documents in AEC room 400 shall be the definitive revision of the document. This copy of the document must be read and understood by all participating students.

Changes

All students involved in the LFEV project will be notified of any and all revisions to the safety plan before the revised plan goes into effect. The definitive copy of this document in AEC room 400 must be replaced with every new revision, and any participant in the safety plan must review and agree to comply with all alterations to the document.

Design Requirements

References

All systems designed for the LFEV project must adhere to the safety guidelines in GPR005 of the 2016 LFEV Statement of Work and the referenced 2016 SAE Formula Hybrid Rules. All designs must be peer-reviewed and specifically verified to follow the safety guidelines established in these documents.

Guidelines

TSV Accumulator Pack

Assembly of the accumulator is to be completed entirely except for the following:

- Cells, and all components associated with their installation into the accumulator including, but not limited to:
 - Aluminum bar wires

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- Cell hold down
- Top panel
- 30 A power connector to PacMan

This is considered the 'safe assembly state'. Further assembly must be done only after approval of this safety plan, and after obtaining the appropriate safety approval label.

Final assembly must be done in its entirety by a single person without interruption to prevent a hazardous state of partial assembly.

Charging with the low current port may be done only with the TDK Lamda charger. Charging is limited to 20 A and 30 V.

Discharge with the low current port will only be done with the Transistor Devices load. Discharge current is limited to 20 A.

Charging and discharging through the low current port may be done only in an environment cleared of other materials. No person shall stand or sit within 2 meters of the accumulator or load except as is necessary to connect/disconnect a cable, or interact with the control panel. Such interaction will be limited to what is necessary to complete the test.

Discharging of the accumulator through the high current ports may only be done in an environment cleared of other materials. Discharging will only be done through the Transistor Devices load. No person shall stand or sit within 2 meters of the accumulator or load except as is necessary to conduct the test. This boundary shall apply once (and as long as) the load is connected to the accumulator.

Disassembly to the safe assembly state must be done in its entirety by one person without interruption. The steps are the reverse of assembly, and all the same precautions must be taken. The sealing label must be destroyed, and a new one obtained if the accumulator is to be reassembled.

The TSV pack must be kept in the designated high voltage area while energized with more than one cell. All work on an energized TSV pack must be done within this area, following the operating procedures laid out in this document.

Tractive System Interface

Do not connect unapproved cables or components to the TSI.

The TSI may only be operated in the designated high voltage area when energized above 30 volts, or directly connected to one or more packs. All work on an energized TSI must be done within this area, following the operating TSV Pack procedures laid out in this document.

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Dynamometer

The Dynamometer may only be operated in AEC room 401, following the operating procedures laid out in this document. Maintenance may be performed on any component as long as the system is not energized.

1. Make sure all moving parts have nothing obstructing them
2. Have authorized personnel (Professor Nadovich) energize the system.
3. Once High Voltage is available in the room, it must be vacated
4. An emergency stop button inside the doorway of AEC 401 is available if communication with the throttle or power supply is lost.

Component Selection

TSV

Wires

Wires that carry charge current are selected at 10 AWG, with a calculated ampacity of 44.9 A at 40 degrees C over ambient. PCB traces from the power connector to current sensing resistor are augmented with copper braid. High current wires are 0.5 in by 1 in aluminum bars with a calculated ampacity of 838 A at 40 degrees C over ambient.

Connectors

Anderson Power connectors for the accumulator (J2, P10, and P11 in accumulator.sch) are chosen for charging, with continuous current ratings of 26 A or greater. TE Connectivity connectors (P14 on accumulator.sch and P1 on connectors.sch) are chosen for connecting charging current to PacMan. They are rated for 35 A continuous current.

Fuse holders and fuses (F2 and F3 on accumulator.sch) on the charging wires are rated for 25 A. The high current fuse is a 200 A fuse (F1 on accumulator.sch) that melts after 150 sec at 350 A.

ITT Cannon connectors (P3 and P4 in accumulator.sch) were chosen for high current output connectors. They are rated for 400 A continuous current.

Other Components

The charge relay on PacMan (RLY2 on safety_loop.sch) is rated for 20 A continuous current

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The current sensing resistor on PacMan (R3 on power.sch) is rated for 1 W. 20 A through the 1 mOhm resistor will dissipate 400 mW.

The AIR relay (RLY1 on accumulator.sch) is a Gigavac relay rated for 350 A continuous current.

Operating Procedures

Any work involving the components listed in this section must follow the procedures listed below. If any component not listed has components that exceed 30 volts but has no procedure listed below, a safety plan must be developed and listed before any work can be done on the system.

Opening the TSV Pack

Process Restrictions

Restricted Spaces

Only people working directly with the pack may be within the HV area

No nonessential objects on the same surface within 1 meter of the TSV Pack

No more than 3 people may work on the TSV Pack at any given time

Safety Manager

A safety manager must be appointed to ensure safety practices are followed

They must remain outside the HV area, with a direct view of the work

They must wear safety glasses at all times, and must carry a cell phone

Equipment

All tools used inside the TSV Pack must be insulated

Only cotton or wool clothing may be worn when working in the HV area

Safety glasses must be worn at all times while working in the HV area

No metal finger rings or loose metal jewellery are allowed in the HV area while work is being performed

Process

Opening The Pack

1. Approve plan of action with qualified instructor
2. Appoint safety manager
3. Clear high voltage area of non-participating personnel
4. Clear TSV Pack work area
5. Proceed with approved plan of action

WARNINGS

Do not connect the TSV Pack to anything outside of the high voltage area

Only one loose cell may be outside of the HV area or room 401 at any time

There must be an emergency stop reachable from outside of the HV area

Operating the TSV Pack

Process restrictions

Restricted Spaces

Only one person, working directly with the pack, may be within the HV area

Safety Manager

A safety manager must be appointed to ensure safety practices are followed

They must remain outside the HV area, with a direct view of the work

They must wear safety glasses at all times, and must carry a cell phone

Equipment

Only cotton or wool clothing may be worn when working in the HV area

Safety glasses must be worn at all times while working in the HV area

Process

Charge*/Discharge

1. Approve the plan of action with a qualified instructor
 2. Appoint safety manager
 3. Clear the HV area of people not involved in the operation
 4. Connect pack to power supply or load
 5. Activate power supply or load
 6. Monitor charge*/discharge
 7. Deactivate power supply or load
 8. Disconnect pack from power supply or load
- * During charge, when the SOC is <90% and the HV area is marked as charging, the safety manager may leave for up to 30 minutes
 - * During charge, the safety manager may give the position to another person. This person must acknowledge the responsibilities before taking the role

WARNINGS

Do not connect the TSV Pack to anything outside of the high voltage area

There must be an emergency stop reachable from outside of the HV area

Running the Dynamometer

Process restrictions

Restricted Spaces

No one may be in room 401 while the dynamometer is being operated

Safety Manager

A safety manager must be appointed to ensure safety practices are followed

They must have a direct view of room 401

They must wear safety glasses at all times, and must carry a cell phone

Process

Startup

1. Have a qualified instructor untag and unlock the power supply switch
2. Turn on power supply (but do not activate)
3. Clear dynamometer of loose tools or other obstructions
4. Clear everyone from the room
5. Set warning tape across the room 401 door
6. Begin running tests from remote computer interface

Shutdown

1. Shut down power supply output remotely
2. Remove room 401 warning tape
3. Turn off power s
4. Have qualified instructor retag and relock power supply switch

WARNINGS

Only a qualified instructor may untag and unlock the power supply switch

Ensure the power supply switch is tagged out before performing any work

The motor should never be operated with an individual in the same room

There must be an emergency stop located outside of the danger zone

Sealing the TSV Accumulator Pack

Process restrictions

Restricted Spaces

Only one person, working directly with the pack, may be within the HV area

Safety Manager

A safety manager must be appointed to ensure safety practices are followed

They must remain outside the HV area, with a direct view of the work

They must wear safety glasses at all times, and must carry a cell phone

Equipment

Only cotton or wool clothing may be worn when working in the HV area

Safety glasses must be worn at all times while working in the HV area

Insulating tools must be used for this procedure

Process

Sealing

1. Approve the plan of action with a qualified instructor
2. Appoint safety manager
3. Clear the HV area of people not involved in the operation
4. Install cells with hold down bars
5. Install the aluminum bar wires
6. Plug in the PacMan 30 amp connector
7. Close the case
8. Attach an obtained safety approval label, signed by a qualified individual, across a fastener that must be removed to access the cells

WARNINGS

Do not connect the TSV Pack to anything outside of the high voltage area

Sealing the TSI High Voltage Section

Process restrictions

Safety Manager

A safety manager must be appointed to ensure safety practices are followed

They must carry a cell phone

Process

Sealing

1. Approve the plan of action with a qualified instructor
2. Appoint safety manager
3. Clear the area of people not involved in the operation
4. Mount the TSI high voltage section in the designated housing
5. Connect cables and wires as indicated in the system design
6. Close the housing
7. Attach an obtained safety approval label, signed by a qualified individual, across a fastener that must be removed to access the interior

WARNINGS

Do not energize the high voltage section of the TSI until the housing is sealed