



## **SUPPLEMENTAL COMMON RULES FOR ELECTRIFIED VEHICLES (SCREV)**

**Note:** *This introduction is provided for information purposes to aid in understanding the structure and program applicability of the SCREV.*

The intent of the Supplemental Common Ruleset for Electrified Vehicles (SCREV) is to provide program boards with recommendations and guidelines for the incorporation of electrified vehicle safety rules and requirements within their programs with a desired outcome of commonality of policy and language across all Club activities.

The SCREV consists of five sections:

### **SECTION 1**

Participating with Electrified Vehicles provides rules related to the applicability and interpretation of the SCREV. A key element of this section is the "Order of Precedence" (1.2), which provides guidance if there is a conflict between the program rules, the SCREV, or the event-specific supplemental regulations.

### **SECTION 2**

Required Event Equipment provides rules for the required Personal Protection Equipment (PPE) for specific SCCA workers and marshals when electrified vehicles are competing in an SCCA event.

### **SECTION 3**

E-Safety provides the necessary training for SCCA competitors, workers, and marshals when electrified vehicles are competing in an SCCA event. Depending on the role, this training can range from a simple E-Awareness briefing to comprehensive training for primary responders.

### **SECTION 4**

Vehicle and Driver Safety Equipment provides the required safety equipment for electrified vehicles and their drivers. Since the inherent danger to the driver of an electrified vehicle can vary with program, some safety rules in Section 4 of the SCREV may only be applicable if other safety equipment is also required by the program or if a vehicle is prepared to a certain level. Some examples:

- Traction System Active Lights (TSALs) are only required if the vehicle is required to have a roll cage per the program-specific rules (Section 4.1.1). Put another way, electrified vehicles that do not have a roll cage installed vehicles also do not need TSALs.
- Tractive System Monitoring Points (TSMPs) are only required if the vehicle has a bespoke powertrain or if the OEM powertrain has been modified in any way. Put another way, if the powertrain is completely OEM and not physically modified in any way, TSMPs do not need to be installed.

It is important to note that program-specific class or category rules have a higher order-of-precedence than the SCREV. As such, a rule in the SCREV may be superseded by a vehicle's class/category rules. Furthermore, additional safety rules may also be required for a vehicle's class/category beyond what is required by the SCREV. Therefore, it is important for each program to consider this order-of-precedence when implementing these common rules and/or generating class/category rules within the programs. This is true for EV-specific classes/categories as well as mixed classes/categories (i.e., EVs competing alongside internal combustion vehicles)

## **SECTION 5**

Glossary provides a common vocabulary for Electrified Vehicle terms across all programs.

Below is a “top-level” summary and general guidance of how the SCREV may be applicable to each program.

### **HILLCLIMB**

All SCREV sections are applicable.

### **RALLYCROSS**

All SCREV sections may be applicable except 4.2 (Driver’s Safety Gear) 4.4 (Fire Systems), and 4.11 (TSALs). Additionally, Sections 4.10 (TS Kill Switches), 4.12 (TSMPs), and 4.13.B (Non-OEM Powertrains) may not be applicable for electrical vehicles running in the Stock Category.

### **ROAD RACING**

All SCREV sections are applicable. Additional safety rules may be applicable as defined by the EV-specific category or class rules.

### **ROAD RALLY**

The SCREV is not applicable unless stated in the event-specific Supplemental Regulations.

### **SOLO**

All SCREV sections may be applicable for all categories. However, certain SCREV sections may be superseded by class/category rules (e.g., SCREV Section 4.2 (Driver’s Safety Gear)). Electrified vehicles running unmodified OEM powertrains are exempt from 4.10 (TS Kill Switches), 4.12 (TSMPs), and 4.13.2 (Non-OEM Powertrains)

### **TIME TRIALS**

Applicable to SCCA sanctioned time trial events. Electrified vehicles requiring only Safety Level 1 may not require SCREV Sections 4.2 (Driver’s Safety Gear) or 4.4 (Fire Systems). Electrified vehicles running Sport or Tuner categories may not require SCREV Sections 4.10 (TS Kill Switches), 4.11 (TSALs), 4.12 (TSMPs), and 4.13.B (Non-OEM Powertrains)

As electrified vehicle technology and safety guidance evolve, the SCREV will also evolve to support the SCCA and its members. Program Boards will be notified of revisions of the SCREV for incorporation in their programs. Suggestions on rules changes and/or improvements to the SCREV can be submitted through the instructions in Section 1.4.

# Common Ruleset and Guidelines for Electrified Vehicles

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## 1. PARTICIPATING WITH ELECTRIFIED VEHICLES

The Supplemental Common Ruleset for Electrified Vehicles (SCREV) address the required elements to ensure the safety of all drivers, volunteers, and track workers when electrified vehicles are entered in an event.

### 1.1. Applicability

This Common Ruleset is generated by the SCCA Electrical Vehicle Advisory Committee (EVAC) to provide program boards with recommendations and guidelines for the incorporation of electrified vehicle safety rules and requirements within their programs.

Many of the rules within the SCREV are only applicable if certain safety equipment is required by the program or if the powertrain is non-OEM. As such, the paragraphs in Section 4.0 include an informational "Potential SCCA Program Applicability" to aid in the identification of rules that may not be applicable for all electrified vehicles.

To support the commonality of EV safety and policy across SCCA, program boards should minimize the modification of this common ruleset language when generating program-specific EV rules and requirements.

### 1.2. Order of Precedence

The following order of precedence shall be followed when incorporating this common ruleset within the various programs:

- A. Applicable Laws and Local Regulations
- B. Event Specific Supplemental Regulations
- C. Specific electrified vehicle class rules
- D. General electrified vehicle category rules
- E. This Common Ruleset
- F. General Technical Specifications or Safety Rules for the sanctioned event.

### 1.3. Interpretation

Interpreting these supplemental competition rules shall be logical as they cannot cover all possible situations. Words such as "shall" or "shall not", "will" or "will not", "cannot", "may not", "are" or "must" are mandatory; and words such as "may" and "should" are permissive.

The interpretation and application of these supplemental competition rules by SCCA officials is final and binding.

The pronouns "he", "his", and "him" are generic and are not intended to indicate gender.

### 1.4. Request for Rules Change

The Electric Vehicle Advisory Committee (EVAC) is responsible for the generation and maintenance of the Supplemental Common Ruleset for Electrified Vehicles. A request to change any rule contained within this document can be made by submitting a letter through Club Racing letter portal at [www.crbscca.com](http://www.crbscca.com).

## **2. REQUIRED EVENT EQUIPMENT**

Additional event equipment may be required when electrified vehicles are competing as defined in the following paragraphs.

### **2.1. Personal Protective Equipment (PPE)**

Specific PPE must be assigned and available to SCCA Members when electrified vehicles are competing in an SCCA event for specific roles only:

- A.** Tow Vehicle Operator: One set of insulating gloves per member
- B.** Wrecker Operator: One set of insulating gloves and a face shield per member. Additionally, each vehicle must be equipped with a safety hook
- C.** Electrified Vehicle Emergency Response Marshal (See 3.4): One set of insulating gloves and a face shield per member.

It is recommended that one set of insulating gloves, one face shield, and one insulating hook be available and easily accessible at all SCCA events.

Rubber insulating gloves must have a minimum Class 0 rating per ASTM D120 and appropriate leather outer protectors meeting ASTM F696. Gloves are to be checked for holes, tears, cuts, or damage prior to the start of each event. Periodic recertification of rubber insulating gloves is recommended.

Face shields must meet ANSI Z87.1 and be in good condition.

Insulating safety hook must be rated for at least 1000 VDC. Safety hooks with handles tested to ASTM F-711 meet this rule.

Use of Personal Protective Equipment is not required for staff employed by the track or facility operating a wrecker or tow vehicle. However, it is recommended that event organizers coordinate with the track or facility in determining appropriate PPE for staff employed by the track or facility to safely respond to electrified vehicle incidents.

### **2.2. Fire Truck**

If the event requires a fire truck, the fire truck shall be equipped to fight both internal combustion and electrified vehicle fires.

Due to the differences in responding to an electrified vehicle fire, it is recommended that event organizers coordinate with local emergency services and the track/facility in developing any emergency plans for responding to an electrified vehicle fire.

Fire extinguishants used to control and extinguish vehicle fires must meet all local regulations and should be environmentally friendly.

### **2.3. Tow Vehicles**

All four wheels shall be decoupled from the road surface when towing an electrified vehicle at speeds greater than 5mph. Using a tilt-bed, dollies or wrecker is recommended for towing an electric vehicle at speeds greater than 5mph

Operators of tow vehicles should be briefed on the inherent dangers of towing electrified vehicles at the start of the event.

The Emergency Services Guide or vehicle's owner manual should be consulted prior to any towing

operation.

#### **2.4. Fire Extinguishers**

If the event has corner or flagging stations, each station should be equipped with at least one nominal 10-pound UL 60 ABC rated or CO2 extinguisher per station.

Nominal 10-pound UL 60 ABC rated, or CO2 extinguishers should also be available at all locations where an electrified vehicle's tractive system is active (pit, grid, impound, etc.)

*Note: Fire extinguishers are only to be used to assist the driver egressing the vehicle in case of a vehicle fire.*

### **3. E-SAFETY**

E-Safety training may be required for SCCA workers, volunteers, and staff when electrified vehicles are competing. E-Safety training rules do not apply to staff employed by the track or facility.

#### **3.1. Worker E-Awareness Briefing**

The Worker E-Awareness Briefing covers basic information about electrified vehicles, how to identify them, and their safety hazards. It is designed such that a briefing can be held at the start of each event.

SCCA workers in hazardous or "hot" areas of the track/facility must be Worker E-Awareness briefed whenever electrified vehicles are on track. Participating in an E-Awareness Briefing is also recommended for any event participant (driver, competitor, volunteer, etc.) when electrified vehicles are participating.

Any worker that has completed the Level 1 E-Safety Training in 3.2 can lead a Worker E-Awareness Briefing

#### **3.2. E-Safety Training - Level 1**

Level 1 E-Safety Training covers information regarding the use of personal protective equipment and the associated dangers of working with electrified vehicles.

All competitors driving an electrified vehicle (including those holding competition licenses issued by SCCA-approved organizations) and all crew members supporting an electrified vehicle must have a valid Level 1 E-Safety Training certificate. In addition to this training certificate, competitors and crew must follow all safety guidelines and procedures as noted in their vehicles service manual.

The safety steward (or designated safety officer for the event) and one scrutineer (or technical inspector) holding an active Level 1 E-Safety certificate must be on-site at the track/facility whenever Electrified Vehicles are on track.

Level 1 E-Safety Training is recommended for all workers in hazardous or "hot" areas of the track/facility.

Level 1 E-Safety Training will expire three years after the completion of the training.

#### **3.3. E-Safety Training - Level 2**

Level 2 E-Safety Training is reserved for future allowances regarding self-designed and bespoke vehicle preparations in SCCA Programs.

#### **3.4. Electrified Vehicle Emergency Response**

Responding to an incident involving an electrified vehicle requires special training to extinguish RESS/Battery Pack fires and avoid electrical shock during extrication.

If an event requires a wrecker, and the wrecker is staffed with SCCA members, at least one wrecker operator trained in electrified vehicle emergency response must be on-site and stationed for dispatch whenever electrified vehicles are on track. Training can be either administered by SCCA, a third-party (such as NFPA), or as part of municipal electrified vehicle incident response training program.

Electrified Vehicle Emergency Response Training is recommended for response marshals, any response vehicle operated by the track/facility, or by hired services.

Information regarding electrified vehicle incident response can be found in the NFPA Emergency Field Guide ([www.evsafetytraining.org](http://www.evsafetytraining.org)).

#### **4. Vehicle and Driver Safety Equipment**

Additional safety equipment may be required for electrified vehicles as defined in the following sections

##### **4.1. Charging**

Potential SCCA Program Applicability: All

Electrified Vehicles shall not be charged in any hazardous or "hot" areas, including Pit and Grid. No work may be performed on the car while connecting or disconnecting charging equipment. The tractive system shall not be worked on while actively charging the vehicle.

For vehicles using a bespoke, prototype, or modified powertrains, the Battery Monitoring System (4.13.B.3) and the Insulation Monitoring Device (4.12) must be active during charging. The BMS must interrupt all charging current when the charge limit has been reached and/or if a fault occurs (over-voltage, under-voltage, over-temperature, etc.). Additionally, the IMD must interrupt all charging current when the insulation resistance between the tractive system and the grounded low-voltage system is less than 100 Ohm/Volt.

Vehicles with complete and unmodified OEM powertrains should refer to the powertrain's manual for charging the energy stores.

Towing a vehicle to perform charging through the regenerative brakes is prohibited.

##### **A. Charging Systems (On-vehicle)**

Potential SCCA Program Applicability: All

All electrified vehicles with on-board charging systems must use an EVSE to charge from a nominal 120VAC or 240VAC electrical supply. EVSE must be unmodified, in good condition, and free of any exposed conductors. It is recommended that EVSEs be listed to UL 2594, CSA 22.2 #28.13, or equivalent safety standard.

For production based electrified vehicles, the on-board charging system must be OEM and shall not be modified (hardware or software) to exceed its maximum rated power.

A standard National Electrical Manufacturers Association (NEMA) interconnect, such as NEMA 15-50, must be used to interface a competitor's portable EVSE with a track/facility electrical service. Hardwiring of a competitor's EVSE to the facility's electrical service is prohibited. It is the responsibility of the competitor to ensure a compatible electrical interface is available from the track/facility prior to the event.

EVSE outlet plug must physically connect to the charging system inlet without modification and be compatible with the vehicle's signaling/communication protocol (e.g., SAE J1772, IEC 62196, etc.).

On-Board charging system may be left unattended once the charging session with the EVSE has been successfully initiated.

##### **B. Chargers/EVCEs (Off-vehicle)**

Potential SCCA Program Applicability: All

All electrified vehicles utilizing an off-board charger or EVCE with a maximum output power of less than (or equal to) 20kW must:

1. be galvanically isolated between the AC input and DC output,
2. be unmodified, in good condition, and free of any exposed conductors or contacts,
3. be housed in a conductive enclosure that is connected to the Protective Earth (Ground) of the AC input.
4. have DC output cables that are orange in color.

Charging with an off-board charger must be continually monitored by a competitor (or their crew) at all times.

**C. DC Fast Charging**

Potential SCCA Program Applicability: All

DC Fast Charging (maximum output power of greater than 20kW) is allowed when using one of the following DC Fast Charge standards:

1. SAE Combined Charging Standard (CCS)
2. CHAdeMO
3. North American Charging Standard (NACS)

The DC Fast Charging EVCE must be unmodified, in good condition, and free of any exposed conductors. The EVCE must either be a permanently installed charging station or be listed to a nationally recognized safety standard (UL2202, IEC 61851-23, etc.).

Vehicles with bespoke, prototype, or modified-OEM powertrains (including custom wiring) must be continually monitored by a competitor (or their crew) while actively charging with a DC Fast Charging EVCE.

**4.2. Driver Safety Gear**

Potential SCCA Program Applicability: Hill Climb, Road Racing, Time Trials (Safety Level 2/3)

The following safety gear must be worn by the driver when a roll bar or roll cage is also required for the vehicle preparation:

- A. A one-piece driver suit carrying an FIA 8856-2000, FIA 8856-2018, or SFI3-2A/5 or higher e.g., /10, /15, /20) certification label.
- B. Gloves are made of leather or other fire-retardant material.
- C. Shoes, with uppers of leather and/or nonflammable material that at a minimum cover the instep. Ventilation pinholes by the manufacturer are allowed.
- D. Socks are made of fire-retardant material.

- E.** Face coverings (balaclavas) of accepted fire-resistant material for drivers with beards or mustaches. Hair protruding from beneath a driver's helmet shall be completely covered by fire-resistant material. Double-layer balaclavas are recommended. If balaclavas are used voluntarily, they shall be of accepted fire-resistant material.
- F.** Crash helmet per the sanctioned event competitions' rules.
- G.** Head and Neck Restraint Systems (i.e., HANS, etc.) per the sanctioned event competition's rules.

All driver safety gear shall be in good condition and free of defects, holes, or frays.

#### **4.3. Emergency Services Guide**

Potential SCCA Program Applicability: All

At least one physical copy of the electrified vehicle's emergency services guide must be readily accessible in the vehicle's paddock. At a minimum, the emergency services guide must contain the RESS/Battery Pack(s) capacity, battery cell chemistry, location of service disconnect(s), a rescue sheet, towing instructions, and information on responding to a vehicle fire. The physical copy must be in its own binder or folder, legible, and available to be provided to Emergency Services in case of an incident. It is recommended a second copy of the emergency services guide be on-hand with the crew when the vehicle is on track.

Any modification of the vehicle from the OEM configuration must be noted in an appendix to the OEM guide.

Vehicles that cannot reference an OEM guide must create an emergency services guide for the electrified vehicle. Guide must be approved by SCCA Technical Services prior to participating in a sanctioned event. Note: A standard SCCA approved Emergency Services Guide is in-progress and will be available at a future date.

#### **4.4. Fire Systems**

Potential SCCA Program Applicability: Hill Climb, Road Racing, Time Trials (Safety Level 2/3)

##### **A. Fire System (Driver Protection)**

An on-board fire system shall be installed in the electrified vehicle when a roll bar or roll cage is also required.

There shall be a minimum of two fire nozzles installed on an electrified vehicle. The nozzle(s) shall be placed external to the RESS/Battery Pack(s) and in a way to provide a barrier between the RESS/Battery Pack(s) and the driver in case of fire.

The fire system must be listed on FIA Technical Lists No. 16, FIA Technical List No. 52, SFI 17.1 or SFI 17.2. Extinguishing medium must have a dielectric strength relative to dry nitrogen at 1 atm greater than 1.0 (such as NOVEC 1230 or FE-36) and must be compatible for the battery cell chemistry used on the vehicle.

##### **B. RESS/Battery Pack Fire Protection**

Fire nozzles designed to directly inject water or extinguishant into a RESS/Battery Pack (including a bespoke RESS) may be used only if the RESS/Battery Pack includes locations(s) for their installation. Modification of the fire nozzle or any commercially available RESS/Battery Pack(s) to install the



nozzle is prohibited.

Extinguishing medium (excluding water) must have a dielectric strength relative to dry nitrogen at 1 atm greater than 1.0 (such as NOVEC 1230 or FE-36) and must be compatible for the battery cell chemistry used on the vehicle.

OEM RESS shall not be modified to install fire nozzles or connect directly to any fire system.

#### **4.5. Firewall**

Potential SCCA Program Applicability: All

Electrified vehicles shall have a separate dedicated firewall between the driver (in the seated position) and motor or motor controller. Any holes in the firewall must be no larger than necessary to allow the passage of controls and cables and must be completely sealed.

#### **4.6. Low Speed Audible Alert**

Potential SCCA Program Applicability: All

Electrified vehicle should generate an audible alert when in a drive mode and traveling below 20mph. The alert sound should be a tone and distinguishable from other noises.

#### **4.7. Participant Personal Protective Equipment (PPE)**

Potential SCCA Program Applicability: All

Competitors of bespoke, prototype, or modified-OEM powertrains (including custom wiring) shall have, at a minimum, a single set of rubber insulation gloves per 2.1.A readily available at the event.

Competitors of complete and unmodified OEM powertrains should have, at a minimum, a single set of rubber insulation gloves per 2.1.A readily available at the event.

It is recommended that all competitors use personal protective equipment listed in the vehicle's service manuals, owner manuals, or component user manuals.

#### **4.8. Secondary Energy Storage Systems**

Potential SCCA Program Applicability: All

Secondary Energy Storage Systems may be used to provide energy to an EVSE, EVCE or off-board charger. Wall mounted energy storage systems should be mounted to a suitable support structure (such as a trailer wall). Commercially available EVSEs/EVCEs with integrated portable storage are allowed. It is recommended that secondary energy storage systems be UL listed for the components of the system (UL 1642 for cells, UL 1791 for inverters, UL 9540 for the system, etc.).

#### **4.9. Service Disconnect**

Potential SCCA Program Applicability: All

Each RESS/Battery Pack must have at least one service disconnect. Location of the service disconnect(s) must be clearly defined in the vehicle's Emergency Response Guide (see 4.3).

#### **4.10. Tractive System Kill Switches**

Potential SCCA Program Applicability: Hill Climb, RallyCross (All categories except Stock), Road Racing, SOLO (Street Prepared, Street Modified, Prepared, and Modified Categories), Time Trial (Max and Unlimited Categories)

Except for vehicles with complete and unmodified OEM powertrains, electrified vehicles must have at least

two tractive system kill switches. One switch must be a Driver Master Switch (DMS) that is capable of being operated by the driver when seated in the driving position with the safety harnesses fastened and the steering wheel in place. The second switch must be accessible from outside the vehicle and located no greater than 6" inside the vehicle. Additional kill switches may be installed if they meet the rules for a DMS or an externally accessible switch..

The tractive system kill switches must be either be rotary mechanical type with a red removable key OR red push-pull/push-rotate emergency switches (Big Red Buttons or BRBs). If rotary mechanical type switches are used, the switch must be installed such that the key is horizontal when in the ON (electrically closed) position and that the key can only be removed when in the OFF (electrically open) position. If BRBs are used, they must have a minimum diameter of 1.5" (40mm) and be electrically open when in the "pushed" position. Both types of switches must be direct acting (i.e., not using logic or relays) to interrupt the control current to the coils of the Insulator Relays (4.13.A.5).

When a shutdown button is pushed or the rotary key switch is opened (off-position), it must:

- A.** Disable the vehicle's tractive system.
- B.** De-energize the motor-controller bus voltage and be less than 60V within 5 seconds (Voltage will be measured at the Tractive System Monitoring Points (see 4.12).
- C.** Interrupt all current from the auxiliary battery and/or DC to DC converter to the grounded low voltage system. A secondary contactor on the switches and/or relay may be used to interrupt this current. Active fire suppression systems powered by the grounded low voltage system are exempted.

All kill switches must be clearly marked by the international marking of a spark in a blue triangle (Figure 1). For rotary mechanical type kill switches, the marking must be above or below the switch such that the "flag" key in the OFF-position points to the word "OFF" in the decal.

**Figure 1:** Required marking for kill switches



#### **4.11. Tractive System Active Lights (TSALs)**

Potential SCCA Program Applicability: Hill Climb, Road Racing, SOLO (Prepared and Modified Categories), Time Trial (Max and Unlimited Categories),

At least one tractive system active light must be installed on electrified vehicles if a roll cage is required. The TSAL must be lit whenever the tractive system is active. Lights must be amber in color, flash between 1-5Hz, and be clearly visible in bright sunlight. Location of the TSAL(s) are as follows:

- A.** GT and Production Based Vehicles: Three TSALs are required. All TSALs must be a minimum of 4" in length
- 1.** One TSAL must be located behind the windshield (or windscreen). If no windshield (or windscreen) is present, light must be mounted on the vehicle's dashboard. TSAL must be on the centerline of the vehicle, be pointed to the front of the vehicle, and be easily visible through the windshield or windscreen (if present).
  - 2.** One TSAL must be mounted to the left and right side of the vehicle. Each light must be located near the A-Pillar and be no lower than the top of the front wheel opening.
  - 3.** Open cage GT and Production based vehicles may install a single TSAL meeting the Formula and Sports Racing rules below.
- B.** Formula and Sports Racing Cars: TSAL(s) must be located near the top of the main roll hoop and in a manner that will not allow contact with the driver's helmet. Light(s) must be visible from the front, left, and right side of the vehicle (except for small angles which are blocked by the main roll hoop).

Electrified vehicles that do not require roll cages may install TSALs so long as they meet the above rules.

#### **4.12.** Tractive System Measuring Points (TSMPs)/Insulation Monitoring

Potential SCCA Program Applicability: Hill Climb, RallyCross (All categories except Stock), Road Racing, SOLO (Street Prepared, Street Modified, Prepared, and Modified Categories), Time Trial (Max and Unlimited Categories)

Except for vehicles with complete and unmodified OEM powertrains, two Tractive System Measuring Points, a Ground Reference Point, and Insulating Measurement Device (IMD) indicator lights are required.

One TSMP must be electrically connected to the positive terminal of the motor controller power bus and one TSMP must be electrically connected to the negative terminal of the motor controller power bus. The TSMPs must be red 4mm shrouded banana jacks, be rated for the nominal Tractive System voltage and be labeled "HV+" and "HV-," respectively. A 10kOhm current limiting resistor, located within 6" of the motor controller bus connection point, must be placed in series between the motor controller bus and each TSMP. Wiring from the motor controller bus to the TSMPs shall be a minimum of 18 AWG, be orange in color, be thermally rated for a minimum of 90°C and be electrically rated for the maximum bus voltage.

The Ground Reference Point must be electrically connected to the vehicle chassis and at a location near the RESS/Battery Pack(s). It must be a black 4mm shrouded banana jack, rated for the nominal Tractive System Voltage, and be labeled "GND." Wiring for the Ground Reference Point shall not be orange in color.

The TSMPs and the Ground Reference Point must be protected within a single waterproof and non-conductive housing that is accessible from the exterior of the vehicle and without the removal of body panels. Location of the TSMP enclosure and wire routing between the motor controller bus and the TSMP enclosure must be fully contained within the roll-over protection structure of the vehicle.

A vehicle-specific Insulation Monitoring Test Cable must be available for technical inspection. The cable will be placed between HV+ and GND (or HV- and GND) and must induce an Insulation Measurement Fault within 60 seconds. The test cable must include a series resistance of 50 Ohm/V and be rated for the expected power dissipation during test. A direct-short between a TSMP and GND for the test cable is prohibited.

The IMD insulator lights must display the state of the insulating monitoring device whenever the grounded low voltage system is energized. If no insulation monitoring fault is present, a green indicator light must be illuminated. If an insulating monitoring fault is present, a red indicator light must be illuminated. The indicator lights must be located on the centerline of the vehicle, forward of the rear axle, and visible in bright sunlight. Indicator may consist of a single two-color element or two single elements (one red, one green)

Insulation monitoring faults cannot be reset by a competitor seated within the vehicle.

#### **4.13. Tractive System Wiring**

Potential SCCA Program Applicability: All

All tractive system wiring must be in good condition. Chaffed, nicked, or damaged wire insulation must be replaced. Electrical connectors or stress relief glands with physical damage must also be replaced. Repair of wiring, connectors, or stress-relief glands is prohibited.

All tractive system conductors (aluminum or copper used for the flow of electricity) must be protected from human contact. Any conductor will be considered "unprotected" if a technical inspector can make physical contact with the conductor using a 10cm (4 inch) long, 0.6 cm diameter (0.25 inch) non-conductive probe.

The determination if a wire is part of the tractive system is solely based on whether it is galvanically isolated from the vehicle chassis.

##### **A. OEM Powertrains**

Potential SCCA Program Applicability: All

Vehicles using complete and unmodified OEM powertrains shall not modify the tractive system components in any way. This includes but is not limited to motor, motor controller, RESS/Battery Pack, wiring, harnesses, conduit, component housing, or mount points. Replacement tractive system components must be OEM.

A complete and unmodified OEM powertrain may be used in a vehicle it was not originally designed for as long as it meets the above criteria.

##### **B. Non-OEM Powertrains**

Potential SCCA Program Applicability: Hill Climb, RallyCross (All categories except Stock), Road Racing, SOLO (Street Prepared, Street Modified, Prepared, and Modified Categories), Time Trial (Max and Unlimited Categories)

Vehicles using bespoke, prototype, or modified-OEM powertrains (including custom wiring) must meet the following:

##### **1. Wire**

All tractive system wires must be thermally rated for a minimum of 105°C and be electrically rated for the maximum tractive system voltage. Tractive system conductors must be of a wire gauge rated for the time-averaged current it may carry (see Table 1 for recommended wire ratings).

Orange shielded and dual-insulated wire compliant to ISO 6722, ISO 14572, or ISO 19642 must be used in tractive-system conductors of 14AWG or larger (RESS/Battery Pack output, motor controller input, motor drive, DC-DC converter input, etc.). Wire shielding must be electrically connected to the vehicle chassis. Paralleling conductors that require shielded and dual-insulated wire is prohibited.

Tractive System wiring used for low-current signaling or communication between the RESS/Battery Pack, Motor Controller, Motor, or other tractive system enclosure must be orange in color and/or placed in orange conduit.

With the exception of wiring to the motor, all tractive system wiring must be contained within the vehicle's crash structure to protect it from impact from another vehicle.

Wire, harnesses, or conduit that are not part of the tractive system shall not be orange in color.

## **2. Interconnection**

All tractive system wiring interconnection must use an electrical connector or a bolted connection. Soldering in any high-current path is prohibited.

### **a. Connectors**

Electrical connectors must be rated for the physical wire gauge installed and electrical current passing through it. Connectors cannot not be physically modified. If a connector is used for shielded and dual-insulated wire, one side of the interconnect must be bulkhead-style and be securely mounted to a high-voltage enclosure. Connectors should be IP-Rated to protect against dust and moisture.

Each RESS or Battery Pack must have a High Voltage Interlock (HVIL) on any output connector wired to the contactor output of the isolation relays (4.13.B.5).

With the exception for high-voltage safety interlocks, tractive system and grounded low voltage wiring cannot be in the same electrical connector

### **b. Bolted Connections**

All bolted connections must be enclosed in a high-voltage enclosure. Wire terminals must be rated for the physical wire gauge and electrical current passing through the bolted connection. The terminal cannot be modified from its original shape except for crimping to the wire it is terminating

The current conduction path through the bolted connection stack-up must be made of copper or aluminum. Steel bolts, washers, and nuts may be used to create a bolted connection, but the steel components cannot be in the current conduction path. Plastic or phenolic in the bolted connections is prohibited. If a nut is used in the bolted connection, the nut must have a positive locking feature such as deformed threads. Ny-locks, lock washer, and thread locking compounds (i.e., Loctite®) cannot be used for this positive locking feature.

All wire entering an enclosure to a bolted connection shall have mechanical strain-relief, such as a strain-relief gland, specifically designed for the wire it is relieving.

## **3. Energy Storage/Battery Management System**

Custom Rechargeable Energy Storage Systems (RESS), Customer Battery Pack(s), or OEM RESS that have been modified in any way must be mounted inside the vehicles' roll structure and must store all tractive system energy.

The RESS/Battery Pack(s) must be securely fastened to the vehicle chassis/roll structure. Mounting brackets and fasteners used to mount the RESS/Battery Pack(s) to the chassis/roll structure must support the entire weight of the RESS/Battery Pack(s) in the event of a vehicle crash (including rollover).

The protective enclosure of each RESS/Battery Pack must provide penetration damage by foreign objects on all sides. Total enclosure wall thickness must be a minimum of 0.125". The use of composite materials with Aramid fiber is encouraged but must be used in conjunction with an aluminum or steel layer. If a composite material with Aramid fiber is used, the metallic layer may be reduced to 0.035" or thicker steel, or 0.059" or thicker aluminum. If no composite material is used, the entire thickness must be made of aluminum or steel. The metallic layer of the enclosure must be connected to chassis ground (4.13.B.6).

Vehicles with roll cages installed should add additional bracing to protect the RESS/Battery Pack from side or rear impact. Brace(s) should be equal diameter and thickness as the main hoop.

The tractive batteries inside each RESS/Battery Pack(s) must consist of commercially available and unmodified battery modules. ELDCs may be used in conjunction with the battery packs or modules if physically located within a RESS. Assembly of individual pouch or cylindrical cells into packs or modules by the competitor is prohibited. Use of prismatic cells with bolted connections are allowed.

The combined cell configuration of the energy stores must be a "nP1S" configuration (i.e., one or more cells in parallel groups that are wired into a single series string). Paralleling multiple battery strings between the tractive system positive and negative voltage bus is prohibited.

All components of the tractive battery (battery modules, prismatic cells, etc.) must be securely fastened to the protective enclosure. Mounting brackets and fasteners must retain the tractive battery components to prevent them from physically moving within or electrically shorting to the protective enclosure during a vehicle crash (including rollover).

All poles of the battery packs/modules must be isolated from the inner walls of the protective enclosure with an insulating material rated for the maximum tractive system voltage. Additionally, a layer of electrically insulating material (such as Kapton or Nomex) is required for all internal walls of the container. The thickness of this insulating layer does not count towards the minimum required 0.125" protective enclosure wall thickness.

A single Battery Management System (BMS) must monitor the tractive battery. At a minimum, the BMS must monitor for over-voltage, under-voltage, and over-temperature conditions. The BMS must alert the driver/crew if any cell drops below the minimum cell voltage limit, exceeds the maximum voltage limit, or the pack temperature rises above the safe operating temperature specified by the manufacturer of the battery cell

#### **4. Fusing**

Each RESS/Battery Pack must have a primary fuse or resettable circuit breaker located on the energy storage side of the isolation relays. Fuse or resettable breaker must be physically located inside the RESS/Battery Pack enclosure or integrated into the Service Disconnect (4.9). All RESS/Battery Pack current shall pass through this primary fuse or circuit breaker. The primary fuse or resettable breaker must be DC voltage rated for the maximum tractive system voltage and current/time rated for the conductors and motor controller it is protecting.

Except for the TSMPs (4.12) and isolator relay pre-charge circuitry (4.13.B.5), all tractive-system branch circuits must have additional fusing within 6" from the branch point to protect the branch circuit. Continuous direct-current (DC) rating of Tractive System branch

fuses must be lower than the rating for conductors and components it is protecting (see Table 1 for recommended fuse ratings) and must be DC voltage rated for the maximum Tractive System voltage

All fuses or breakers, including the primary fuse or circuit breaker, must be located in a fuse holder, or otherwise mechanically mounted per the manufacturer's recommendation.

**5. Isolation Relays**

Vehicle must have at least two normally open isolation relays that can isolate the stored energy on the vehicle from the rest of the tractive system. One relay must be in line with the 'positive' conductor, and one must in line with the 'negative' conductor such that all stored energy is contained within the RESS or Battery Pack enclosure when the relays are open. Each RESS or Battery Pack installed on the vehicle must contain one set of isolation relays.

The coil side of the isolation relays must be powered by the grounded low voltage system through a dedicated safety loop. At a minimum, isolation relays must open if any of the following occur:

- a.** Any Tractive System Kill Switch is opened (4.10)
- b.** RESS/Battery Pack Output Connector(s) HVIL is opened (4.13.B.2.a)
- c.** Insulation Monitoring Device detects an insulation fault (4.12)
- d.** Battery Monitoring Device detects a fault of the energy store (4.13.B.3)
- e.** Auxiliary (GLV) Battery is disconnected.

Isolation relays must be rated for a maximum electrical current greater than the primary fuse of circuit breaker (4.13.B.4). A pre-charge control circuit must be implemented to control the initial charging of the motor control input capacitors prior to closure of the isolator relays.

**Table 1 - Single Conductor Free-Air Wire Current Capacity (DC)**

<b>Wire Gauge Coper (AWG)</b>	<b>Conductor Area(mm<sup>2</sup>)</b>	<b>Maximum Recommended Continuous Conductor/Fuse Rating (A)</b>
24	0.20	5
22	0.33	7
20	0.52	10
18	0.82	14
16	1.31	20
14	2.08	28
12	3.31	40
10	5.26	55
8	8.37	80
6	13.3	105
4	21.2	140
3	26.7	165
2	33.6	190
1	42.4	220
0	53.5	260
2/0	67.4	300
3/0	85.0	350
4/0	107	405
250 MCM	127	455
300 MCM	152	505
350 MCM	177	570
400 MCM	203	615
450 MCM	253	700

**6. Grounding (Equipotential Bonding)**

Any conductive component of the vehicle within 4" (101 mm) from any Tractive System component, enclosure, or wire must have a resistance of less than 300 milli-Ohm to the vehicle chassis. This includes but is not limited to roll cages, body panels, firewalls, metallic, stress-relief glands, high voltage enclosures, and motor housings.

Any component of the vehicle which may become conductive (i.e., carbon fiber body panels or survival cells) vehicle within 4" (101 mm) from any Tractive System component, enclosure, or wire must have a resistance of less than 5 Ohms to the vehicle chassis. The addition of cooper mesh to potentially conductive materials may be necessary to ensure bonding is maintained.

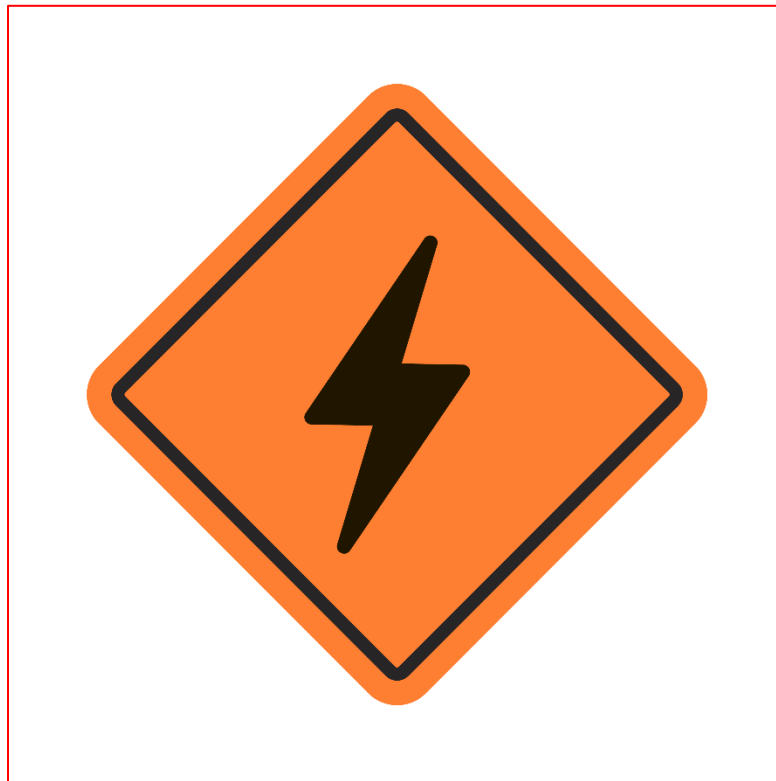
**4.14. Vehicle Markings**

**A. Vehicle Powertrain Identifier**

Potential SCCA Program Applicability: All

Battery Electric Vehicles must be marked on both sides of the vehicle with the SCCA Electric Vehicle Designation Decal 2651 (See Figure 2). Symbol must be placed on the rear side of the vehicle number and must be oriented as shown in Figure 2. Vehicles that require the number on the wing or window may place the diamond symbol on any side panel between the front and rear wheel. Marker must be a minimum of 8" tall by 8" wide (203mm x 203 mm).



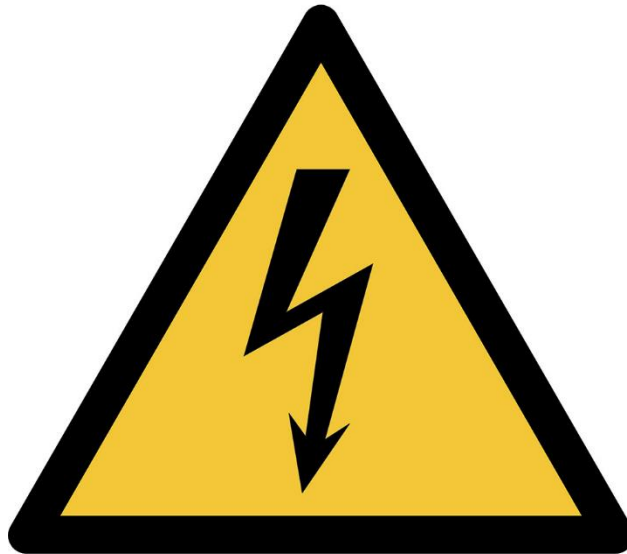


**Figure 2:** SCCA Electric Vehicle Designation Decal (2651)

**B.** High Voltage Warning Symbol

Potential SCCA Program Applicability: Hill Climb, Road Racing, SOLO (Prepared and Modified Categories), Time Trial (Max and Unlimited Categories)

All enclosures containing circuits with a working voltage greater than 60VDC shall be marked with the yellow and black electrical warning triangle per ISO 7010 when roll bar or roll cage is also required (See Figure 3). Each side of the triangle should be 5" on a side but may be reduced to fit on smaller enclosures. Original OEM labels containing the warning triangle do not require additional marking.



**Figure 3:** ISO 7010 Electrical Safety Triangle

## 5. GLOSSARY

**Auxiliary Battery:** Battery used to supply energy to the grounded low-voltage system.

**Auxiliary DC/DC Converter:** Power electronics used to power the grounded low-voltage system and/or charge the auxiliary battery from the tractive battery. The input of the auxiliary DC/DC converter is considered part of the tractive system and the galvanically-isolated output is considered part of the grounded low-voltage system.

**Battery Cell:** Electrochemical energy storage device consisting of a positive electrode, negative electrode, and an electrolyte. Cells may be cylindrical, pouch, or prismatic.

**Battery Management System:** Safety system that monitors and optionally charge balances battery cells.

**Battery Module:** A single unit containing one or more electrically interconnected and mechanically assembled battery cells.

**Battery Pack:** A single mechanical assembly comprising of battery modules, retaining frames, fuses, contactors, and a battery management system. A RESS may have one or more battery packs.

**Capacitor:** Device used to store electric energy in an electric field.

**Charging System (On-Vehicle):** All components and electronics installed on the vehicle used to recharge the RESS/Battery Pack(s) using an EVSE.

**Charger (Off-Vehicle):** Stand-alone electrical device used to recharge the RESS/Battery Pack(s) and directly connected to the electrical supply.

**Conductor:** Aluminum or copper used for the flow of electricity. Conductors may be insulated (i.e., wire) or non-insulated (i.e., terminal lug).

**Electric Double Layer Capacitor (EDLC):** System in which an electric charge is stored. Commonly referred to as a "Super Capacitor" or "Ultra Capacitor".

**Electric Motor:** A rotating machine which transforms electrical energy to mechanical energy. An electric motor may also transform mechanical energy to electrical energy through regenerative braking.

**Electric Shock:** Physiological effect resulting from an electric current passing through the human body.

**Electric Vehicle:** Vehicle where the powertrain is driven solely by one or more electric motors.

**Electric Vehicle Charge Equipment (EVCE):** Device used to convert AC to DC power for the recharging of electrified vehicles.

**Electric Vehicle Service Equipment (EVSE):** Device used to interface the on-vehicle charging system to an AC electrical supply (auxiliary energy storage system, facility power, generator, etc.).

**Electrified Vehicle:** Any vehicle that has at least one RESS or Battery Pack and at least one electric motor.

**First Responder Cut Loop:** One or more loops of wire in the grounded low-voltage system that a first responder physically cuts to disable the vehicle. Typically, cutting this loop will completely disable the tractive system.

**Galvanic Isolation:** Separation of electrical systems such that no direct current conduction path exists.

**Grounded Low Voltage System:** All electric equipment or electronics in the vehicle that is electrically referenced to the vehicle frame.

**Hybrid Vehicle:** Vehicle where the powertrain is driven by a combination of an internal combustion engine and an electric motor.

**Insulation Monitoring Device (IMD):** An electronic circuit that continuously monitors the insulation resistance between the Tractive System and the Grounded Low Voltage System. The IMD may be standalone component in the vehicle or may be part of a RESS.

**Insulation Resistance:** Measurement of isolation between two electrical systems. Units are typically Ohms/Volt.

**Personal Protective Equipment (PPE):** Equipment worn to minimize exposed hazards, such as electrical shock.

**Powertrain:** See Tractive System

**Protective Earth:** Dedicated conductor or mounting point that connects electrical equipment to the Earth ground for the purpose of electrical safety.

**Rechargeable Energy Storage System (RESS):** The complete energy storage device comprising an energy storage medium (typically tractive batteries and capacitors in an electrified vehicle), the components to mount, monitor, manage and protect the storage medium, and everything needed for normal operation of the RESS (except for cooling equipment and liquid).

**Secondary Energy Storage System:** Standalone system consisting of an energy storage mechanism and power conversion electronics used to store energy and is capable of being an electrical supply at a later time.

**Service Disconnect (High Voltage Disconnect or Manual Disconnect):** Electrical disconnect in-line with the primary current path of the tractive system that can be removed as a precautionary measure during the service of an electrified vehicle. The service disconnect(s) may have the primary tractive system fuse built into the disconnect, is generally located on the RESS or Battery Pack(s) and may have secondary contacts to open the isolation relays when disconnected.

**Tractive Battery:** Intermediate storage device of electrical energy and consists of electrically connected battery cells group together in battery modules. The tractive battery supplies energy to the tractive system and may supply energy to the grounded low voltage system.

**Tractive System:** All electric equipment or electronics on the vehicle used for the propulsion of the vehicle and is galvanically isolated from the vehicle frame.

**Wire:** A fully insulated flexible conductor. Multiple wires may be bundled into cables (cable assemblies).