

# EV EDUCATION RALLY

## FULL-SIZE VEHICLE SPECIFICATIONS

The objective is to convert a conventional internal combustion vehicle to an electric vehicle in a safe manner that is in compliance with the following rules and specifications. All vehicles will be inspected prior to any competition and must adhere to all rules and specifications. EV Rally staff have the final interpretation of these specifications.

*All vehicles shall be "street-legal" with a current license tag and appropriate state-required liability insurance. All safety devices and features required of licensed vehicles must be installed and operational.*

*If you have questions regarding interpretations of these specifications or wish to petition for a variance, you must submit your question or information in writing by email to Alan Shedd at [alan@EVEducation.org](mailto:alan@EVEducation.org)*

*Note: In events that require both a driver and passenger, both vehicle occupants must wear the required safety gear.*

### VEHICLE

#### 1. Vehicle Type

Vehicles shall be conversions of internal combustion engine powered passenger vehicles. Vehicles shall have four wheels and shall have originally been designed for two to six passengers. All vehicles shall be model year 1971 or later.

#### 2. Conversion

Fuel tanks and other gasoline or vapor storage equipment shall be removed from the vehicle. The conversion to electric shall not alter the drive train configuration. For example, a front engine, rear wheel drive vehicle shall remain rear wheel drive with the electric drive motor located forward of the driver.

#### 3. Wheel Base

Passenger vehicles shall have an original wheelbase of not less than 80 inches or more than 110 inches. Pickup trucks shall have an original wheel base of not less than 104 inches or more than 122 inches. The original wheelbase shall not be altered by the conversion to electric.

#### 4. Track

The vehicle track shall not be altered by the conversion to electric.

#### 5. Offset

The vehicle shall not have an offset body or frame

#### 6. Vehicle Weight:

The vehicle shall weigh a minimum of 2300 pounds, with the driver and in race configuration. Ballast is permitted but must be securely fastened to prevent movement in the event of a crash. The vehicle, with the driver and in race configuration shall weigh no more than the Gross Vehicle Weight Rating (GVWR) shown on the original manufacturer's door pillar placard. Proof of GVWR will be required if the manufacturer's placard is missing. Teams should pay close attention to maintaining the original weight distributions of the original vehicle. Handling and stability can be adversely affected by improper weight distribution.

#### 7. Height

The vehicle overall height shall be the stock dimension +/- 2.0 inches.

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### 8. Ground Clearance

No portion of the vehicle, including the spoiler/air dam, shall be lower than the lowest part of the wheel rim.

## SAFETY EQUIPMENT

### 1. Roll Cage *(Not required for the EV Rally; however, other competitions may require this item. Keep this in mind as you design your vehicle).*

Vehicles shall have a six point roll cage structure constructed of mild steel tubing with a minimum 1.5" outside diameter and 0.090-inch wall thickness. (All roll bars will be measured for wall thickness using a ruler or ultrasonic tester). The structure must be fully triangulated for strength and securely and safely attached to vehicle's main structure using footplates of a least 3 inches square. The forward part of the cage shall be mounted to the floor of the vehicle, not to the firewall or fender wells. The front hoop bracing shall not pass through the vehicle firewall. Rear hoop bracing may be mounted at the rear shock towers or rear suspension pickup points. Steel gusset plates of 1/8" thick steel shall be used at all major roll cage tube intersections. The cage must have minimum two side-door bars on passenger's and three driver's side (see Diagrams 1 and 2). The driver's side bar may be extended to the outer door skin to achieve this spacing. Inner door panels may be modified or removed if the sidebars are extended. All bars that the driver could come in contact with shall be padded with a minimum of 1 inch of foam. Vehicles equipped with battery enclosures mounted behind the driver shall have a cross bar extending across the entire rear hoop at a height appropriate to restrain the battery enclosure from moving inside the roll cage.

### 2. Fire Extinguisher

A 2 1/2 pound or larger dry chemical IA, 10BC fire extinguisher with a positive indicator showing charged must be securely mounted within the driver's reach using a steel mount with a quick release bracket.

### 3. Safety Belts

A 2-inch wide, 4 point seat belt/shoulder harness or the original lap and shoulder belt shall be installed in the vehicle.

### 4. Driver's Seat

The driver's seat may be replaced with any seat suitable for competition, including a racing type bucket seat. Aluminum seats shall be fabricated from material with a minimum thickness of 0.125 inch. Replacement driver's seat shall be provided with additional seat back support and shall be placed to allow the driver to naturally reach the vehicle controls.

### 5. Steering Wheel

The steering wheel may be of any type but shall not have a wood rim. The center of the steering wheel shall be padded with at least 2 inches of resilient foam material. (If the manufacturer's original steering wheel is used, additional padding is not required.)

### 6. Steering Column

No modifications to the original manufacturer's crushable steering column shall be allowed. No components shall be located in the crush zone existing in front of the steering column and the steering gear box.

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### 7. Headrest

Head support shall be provided behind the driver's head. The support should be adequate to prevent the driver's head from moving backward in the event of a vehicle crash or hitting the roll bar (if equipped) behind the driver's seat. A padded headrest of at least 4 inches by 8 inches shall be securely mounted behind the driver's head.

### 8. Shock Hazards

All voltages greater than 14 volts shall be insulated and protected from incidental contact. No exposed traction battery voltages shall be permitted inside or outside the battery enclosure.

### 9. Lights

The vehicle shall be equipped with standard lighting required of a licensed vehicle (brake, turn, tail, marker, and headlights) equivalent to those supplied by the original manufacturer. These lights shall be operable.

### 10. Horn

Vehicle shall be equipped with a functioning production electric horn.

### 11. Helmet

Each team shall supply their own drivers helmet with a Snell 90 or better rating.

### 12. Eye protection

Safety goggles or full face shield (not glasses) will be required for each team member in the working or charging areas. Rubber aprons and gloves are also recommended.

### 13. Warning Signs

Areas of the vehicle that contain conductors and equipment with high current and voltage greater than 14 V must be marked with "Warning High Voltage" signs.

## **BATTERY SYSTEM**

### 1. Battery Type

Only rechargeable lead acid batteries shall be permitted. The propulsion battery pack voltage shall be 96 volts nominal. No restriction is placed on battery capacity (measured in kWh) as long as maximum battery pack voltage is within the above specified voltage. No restrictions are placed on size or number of cells (however, resulting vehicle weight is a restriction; see "Vehicle Weight").

### 2. Battery Isolation

The battery pack shall be isolated from the chassis (i.e. a floating ground). Batteries shall have less than 5 milli-amps current from both the positive and negative high voltage terminals to the chassis ground. This measurement shall be made with the vehicle controller in the "off" and "on" positions.

### 3. Battery Location

The propulsion batteries shall be placed in the vehicle to minimize polar and roll moments of inertia. Batteries mounted entirely above the rear floor pan (truck compartment) shall not be allowed. Battery enclosures shall not be placed within 2 inches of the outer body.

### 4. Battery Enclosure

Batteries shall be fully contained in non-porous, non-absorbent durable enclosures. The enclosures shall be of sufficient strength to contain the batteries in the event of a crash or overturned vehicle

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and shall enclose the batteries on all sides. Batteries must be restrained from movement in all planes (vertical as well as side to side). This is particularly important when batteries are installed inside the vehicle's passenger compartment. Be careful of acid and water spills within battery enclosure. Even the slightest spill can cause charger and circuit GFIs to trip due to ground faults and leakage current. Batteries must be mounted so that terminals always maintain a safe distance from one another, even in the case of severe jarring or vehicle collision. It is recommended that all battery terminals and conductors be individually covered or sealed with insulating material rated for full DC bus voltage.

### 5. Battery Enclosure Mounting

Battery enclosures shall be securely mounted to structural members of the vehicle chassis. The enclosures must be fastened in multiple locations so as to distribute the inertial load of the pack and adequately reinforced to prevent tearing and breakage. Battery enclosures shall not be mounted inside the front driver and passenger area of the vehicle.

### 6. Battery Ventilation

Battery enclosures located inside the passenger compartment or enclosed space such as the trunk must be gasketed and sealed to prevent vapors from entering space and equipped with forced-air ventilation to the outside of the vehicle to remove gases and vapors. This regulation applies to both sealed and wet-cell batteries. It is recommended that the venting system have the exhaust mounted on the top of the battery enclosure to draw air from the bottom to the top. The fan must be rated at least 10 cfm and be brushless or have an Underwriter's Laboratory explosion-proof rating such that it does not produce sparks. The fan can draw its power from any power source. It must operate at any time the vehicle is operating and during recharging of the batteries. The ventilation systems shall not exhaust to the interior of the vehicle. Battery enclosures located under hoods and truck beds of vehicles should be constructed in a manner to sufficiently allow hydrogen gas to dissipate while the vehicle is being driven and charged.

### 7. Spare Battery Modules

Replacement of failed battery modules shall be permitted prior to or subsequent to competition using spare battery modules. Replacement of modules will not be permitted during an event. Modules shall only be replaced after consulting the EV Rally staff.

### 8. Battery Disconnect Switch

The traction battery shall be equipped with a readily accessible manually operated, high current switch to quickly disconnect the battery from the electrical system. The switch shall be capable of interrupting the full load current. The switch shall be electrically located as near the battery as practical. Operation of the switch shall disconnect all traction battery powered equipment including battery gauges. The battery disconnect shall be operable from inside the vehicle by the driver in a belted-in position. The switch shall be clearly marked as "Battery Disconnect" and be clearly labeled to indicate "On" and "Off" positions. It is recommended that the disconnect switch also be accessible from outside the vehicle. Mounting the disconnect to the left of the steering column may allow it to be reached by the driver or through the open driver's window. (It is recommended but not required that the battery disconnect be located as close to the middle of the battery string as possible so that when off, the battery pack Voltage is divided in half.)

### 9. Baking Soda

All teams shall provide their own baking soda to be used in the pit area in the event of an accidental spill.

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### BATTERY CHARGERS

*To use on site charging, chargers must comply with this section. If you opt to charge off site, compliance is recommended but not mandatory.*

1. General Regulations: Vehicles shall be brought to each event fully charged. Vehicles will operate throughout the day on a single charge. Charging will not be allowed at the location of any competition, except as directed by event officials.
2. All Chargers: Charger AC input and extension cords shall be a minimum of two wire and ground, outdoor rated (SO) cord. Minimum wire size shall be #12 AWG for 20 ampere service and #8 AWG for 50 ampere service. Cords shall be in excellent condition with no splices abrasions or cuts penetrating the outer jacket. Cords shall be rated for use at 400 volts or greater.

DC to DC connections shall either be hard-wired or shall be with a shielded connector that does not allow human contact with the energized terminals. Alligator clips or other temporary connections shall not be permitted.

Charging power should be provided through Ground Fault Current Interrupter Circuit Breakers which will trip free at a ground current (or branch circuit current imbalance) of greater than 5 milliamperes. Chargers shall be capable of operation from this source.

The charger shall be equipped with an output fuse rated for use at 250 volts or greater and an ampacity no greater than 125% of maximum charger DC output.

3. On-board Chargers: Charger connections shall be configured to ensure that the frame of the vehicle is grounded to the AC power supply ground (earth ground) whenever the charge connector is inserted into the vehicle. The ground circuit shall be a minimum #12 AWG for 20 ampere service and #8 AWG for 50 ampere service. Connectors shall be similarly rated. The DC output wires/cord shall be rated for at least 125% of the maximum charger output current. Plug and receptacle electrical connections shall be shrouded to prevent contact.
4. Off-board chargers: DC output cord shall be rated for at least 125% of the maximum charger output current. The outer jacket of this cord shall be rated for outdoor use at a voltage of at least 200% of the charger output. The DC connector to the vehicle shall be polarized and rated for at least 125% of the maximum charger output current. Plug and receptacle electrical connections shall be shrouded to prevent contact.
5. Extension cord: Each team shall provide one UL-listed extension cord, designed for exterior use, at least 30 feet in length and rated for the appropriate voltage and current of your charger. If your vehicle utilizes more than one charger, you must either provide a cord with multiple plug-ins or separate cords for each charger. To avoid excessive voltage drop in the extension cord, a 14-gauge cord is recommended for 15-Amps, 12-gauge cord for 20-Amps, and a 10-gauge cord for 30 Amps.

### MOTOR / CONTROLLER

#### 1. Motor Type

Motors shall be of the direct current type using any configuration of field and mechanically commutated armature.

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### 2. Cables

Cables supplying the motor and controller with traction battery current must be a minimum #2/0 AWG multi-strand copper with an abrasion resistant insulating jacket.

### 3. Battery Cable Routing

Cables energized at traction battery voltage shall be routed to ensure they do not contact moving chassis components. Cables shall be secured to prevent movement. Cables shall not be permitted near the body exterior or in a crush zone where they may be damaged in a collision.

### 4. Traction Battery Fuses

Batteries must be current-limited via at least one fuse (not a circuit breaker) It is recommended but not required that the fuses be located at the middle of the battery string – not at the end. No device of any type shall be connected between the fuse and the battery. Fuses shall be DC rated for a minimum Voltage of 1.5 times the nominal pack voltage and have the following current ratings:

500 amp fuse maximum – for vehicles with motor controller limits of 700 amps

800 amp fuse maximum – for vehicles with motor controller limits of 1200 amps.

### 5. Controller

Controller shall be DC, pulse-width modulating type. Maximum current rating of 1200 Amps at nominal 96 Volts DC input. The controller shall be equipped with a high-pedal disable interlock to prevent energizing the controller with the accelerator depressed. Controller bypass switches are not permitted.

### 6. Accelerator Mechanism

Accelerator mechanisms shall be free moving and shall return to the zero current position when released. At least two energy sources (e.g. springs) shall be provided to return the accelerator to the zero current position. Vehicles equipped with direct drive (no mechanical clutch) shall be equipped with an interlock to prevent the controller from energizing while the accelerator is depressed.

### 7. Energy Use Meters

Energy Meters (kWh or amp-hour) are recommended to help in understanding the efficiency and operation of the electric vehicle. They are not required for competition.

### 8. Contactors

Contactors must be shielded and located outside of driver's area.

## DRIVE TRAIN

### 1. Scatter shield *(Not required for the EV Rally; however other competitions may require this item. Keep this in mind as you design your vehicle.)*

The installation of scatter shields or explosion proof bell housings shall be required on all vehicles equipped with a clutch or flywheel. Chain drive vehicles shall be equipped with a chain case to contain the chain in the event of failure. Motors equipped with a brush replacement window shall be equipped with guards to contain brush and armature explosions. Minimum specifications for scatter shields, chain cases and armature guards shall be:

0.125" SAE 4130 alloy steel

0.250" mild steel plate

0.250" aluminum alloy

NHRA approved and labeled flexible shields

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Scatter shields, chain cases, and armature guards shall be designed to deflect fragments from moving vertically or out to the sides of the vehicle where they might endanger the driver or a bystander. The scatter shields, etc., do not have to prevent the fragments from falling to the ground.

### 2. Motor and Transmission Mounts

Motor and transmission mounts shall be secure and adequate.

### 3. Drive Shaft Loops *(Not required for the EV Rally; however, other competitions may require this item. Keep this in mind as you design your vehicle)*

The vehicle drive shaft shall be fully enclosed by at least two metal loops located near the front and rear universal joints. The loops shall be constructed of at least 0.125-inch mild steel, 1 inch wide.

## INTERIOR

### 1. Mirrors

Inside or outside rear view mirrors shall be required.

### 2. Gauges

The installation, removal or modification of gauges shall be permitted. Gauges shall be securely mounted. An operable speedometer accurate to + 5% shall be installed.

### 3. Dash Pad

Gauges and accessories may be removed from the dash panel. The dash panel itself shall not be modified in any way other than as necessary for roll cage installation if used.

### 4. Rear Seat & Interior Panels

Removal of the rear seat and all associated hardware, headliners, door panels, and carpet shall be permitted. Exposed metal body panels shall be neatly painted. All exposed sharp metal edges shall be covered or protected.

## BODY / STRUCTURE

### 1. Body

Body contours and dimensions shall remain as originally manufactured. The body shall not be lowered on frame. The body shall not be offset on the track centerline or moved in relation to wheelbase. Body panels and floor shall remain unmodified, except as necessary to install batteries, motor, and roll bar. Body panels and bumpers shall be securely installed to remain in normal position, throughout competition.

### 2. Fenders

Fenders and wheel openings shall remain unmodified. It is permitted to roll under or flatten any interior lip on the wheel opening for tire clearance. Removal of non-metallic inner fender panels is permitted.

### 3. Front Spoiler / Air Dam

A front spoiler / air dam shall be permitted. It shall not protrude beyond the overall outline of the body and shall not be mounted more than 4 inches above the horizontal centerline of the front wheel hubs. The spoiler shall not cover the normal grill opening; however the opening can be taped or

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covered separately. Headlight holes / sockets can be covered with standard-type Plexiglas covers to improve aerodynamic efficiency. Aerodynamic skirts shall be prohibited.

### 4. Belly Pan

Covering of the underside of the vehicle shall be allowed. The cover shall be of suitable strength and composition for such service. The panels shall not be visible from the side of the vehicle.

### 5. Towing Eyes

Vehicles shall be equipped with towing eyes, front and rear, suitable for flat towing or hauling the vehicle. The towing eyes shall not protrude beyond the bodywork and shall be easily accessible without removal or manipulation of bodywork.

### 6. Doors

Doors functional and operation. They shall latch securely.

### 7. Hood / Trunk Pins *(Original equipment hood and trunk latches can be used for the EV Rally. Keep in mind that pins may be required at other competition s).*

Original equipment hood and trunk latches should be removed. Hoods should be latched with hood pins. Since batteries are likely to be installed in the trunk area, trunks should also be latched with pins or the equivalent such that the trunk is secure but yet can be quickly accessed without use of a key in case of emergency.

### 8. Windshield

Original equipment front windshields shall be maintained in the original mounting location using the original equipment molding and retainers. Rear windshield and side windows may be replaced with Lexan material at least 1/8 inch thick. Rear windshields replaced with Lexan shall be stock appearing and shall be retained with 6 safety clips (3 inches x 1 inch x 1/8 inch) bolted or riveted to the body, 3 each along the top of the windshield and 3 each along the bottom of the windshield. Working windshield wipers are required.

### 9. Side Windows

Side windows may be replaced with Lexan material at least 1/8 inches thick. The passenger side window shall remain open during competition or can be removed completely.

### 10. Vehicle Numbers

The vehicle number must be at least 12 inches in height with a stroke of at least 1-1/2 inches in width. It must be neatly painted or decaled in a color that contrasts with the body paint for easy identification. Number must be placed on both sides of the car on the center of the door.

## CHASSIS

### 1. Springs and Shock Absorbers

Any spring or shock absorber shall be permitted, provided: (1) they attach to the original mounting points, and (2) springs are of the same type as original and installed in the original location using the original attachment. Substitute struts and/or inserts shall be permitted for MacPhearson strut equipped vehicles. Shackles or spacer blocks between leaf springs and axle shall be permitted. Coil spacers shall not be permitted.



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### 2. Suspension Control

Installation or substitution of any anti-roll bar(s), traction bar(s), panhard rod, or watts linkage s shall be permitted, provided such installation serves no other purpose than suspension control. Mounts for these devices shall be welded or bolted to structural components of the vehicle

### 3. Mounting Points

Camber and caster adjustments shall be made using shims and / or eccentric bushings. Vehicles equipped with MacPhearson strut suspension shall be permitted to adjust camber and caster at the top mounting point using eccentric bushing or slotted adjusting plates.

### 4. Suspension Braces

Vehicles may add one stayrod either, (1) located between lower suspension mounting points, (2) located between the upper strut towers on MacPhearson strut equipped vehicles, or (3) between upper front shock absorber mounts on vehicles with other forms of suspension.

### 5. Hubs, Spindles, and Steering Arms

No modifications to hubs, spindles, and steering arms shall be permitted.

### 6. Bushings

Any bushing material shall be permitted.

### 7. Hardware

Replacement of suspension hardware, such as nuts and bolts, shall be permitted when replaced with similar strength hardware performing the same fastening function. Fasteners shall be equipped with locking nuts, double nuts, or shall be secured with locking wire or cotter pins.

## BRAKES

### 1. Brake

Brakes shall be configured as originally supplied by the OEM. Brake substitution shall not be permitted. Dual-circuit brake systems operated by a single pedal shall be required.

### 2. Brake Materials

Brake pads, brake linings, and brake fluid shall be unrestricted.

### 3. Backing Plates

Backing plates and dust shields may be ventilated or removed. Air ducts shall be allowed, provided they extend in a forward direction and no changes are made to the body.

### 4. Drums / Discs

No modifications to brake drums and/or discs shall be permitted except for truing within the limits allowed by the manufacturer.

### 5. Brake Lines

Replacement of brake lines shall be permitted using steel lines or Teflon lined metal braided hose. Relocation of lines / hose to provide additional crash protection shall be permitted.

### 6. Proportioning Valves

The installation of inline, pressure limiting proportioning valves shall be permitted.

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### 7. Parking Brake

Parking brakes shall remain operable.

### 8. Regenerative Braking

The use of regenerative braking is permitted.

## WHEELS / TIRES

### 1. Wheel Size

All vehicles shall be equipped with at least 13-inch diameter wheels. Vehicles originally equipped with 12 inch Wheels shall be permitted to fit 13 inch wheels. Vehicles originally equipped with 14-inch wheels or metric 390 wheels, shall be permitted to fit 15-inch wheels.

### 2. Wheel Type

Any metal wheel shall be permitted. Knock off or quick-change wheels shall be prohibited.

### 3. Tires

Any DOT rated tire shall be permitted. Racing, recapped, or re-grooved tires shall not be allowed. Tire size shall be suitable for the vehicle's rim width. The only allowed modification to tires shall be to shave or true the tires. However, at least 5/32 inch of tread shall be present at the start of competition. Tires shall be rated for loads at least as great as the heaviest corner weight of the vehicle. Tire warmers or chemical softeners are prohibited.

### 4. Tire Pressure

Tire Pressure at the beginning of any competition shall be less than the rated pressure shown on the tire sidewall. Tire pressure will be inspected prior to the events as well as at technical inspection.

### 5. Tire Replacement

Tires shall not be replaced subsequent to final technical inspection. If a tire fails or is excessively worn, approve from a EV Rally official must be obtained prior to replacement.

### 6. Wheel / Tire Width

Wheel width shall not exceed 7 inches. Tire tread shall not protrude beyond the fender opening.

### 7. Wheel Studs

Wheel studs shall be installed in the size and quantity used by the original manufacturer.

### 8. Spare Wheels

Spare wheels and tires may be removed.

## Additional information

The National Electric Drag Race Association [www.NEDRA.com](http://www.NEDRA.com) in cooperation with the National Hot Rod Association publishes a detailed set of rules and specifications for electric vehicles designed for drag racing. While these requirements exceed many of the requirements of the Electric Vehicle Education Program, they provide valuable information related to the construction of competition EVs.

Other sources of information, rules, and specifications for full-size EV conversions can be found at [www.nesea.org/transportation/tour/](http://www.nesea.org/transportation/tour/) and [www.evchallenge.org/schools/highschool/rules/index.html](http://www.evchallenge.org/schools/highschool/rules/index.html)