

# **EV EDUCATION RALLY**

## **EV Master Teaching Vehicle™ (EM-TV) Specifications**

The objective is to construct an electric vehicle that matches the following specifications. These specifications have been developed by consultants, advisors, and instructors of EV Master, Inc. and the EV Education Program, Inc. as a result of research, teaching, and competitions. They provide a high standard of safety, reliability, and academic value.

You could use the following approaches:

Construct a vehicle that complies with these performance and dimensional specifications. Components need not be purchased as part of a kit from EV Master, Inc. Note that a vehicle constructed to compete in this class must be designed from the “ground – up” as part of a comprehensive engineering design process following these guide specifications. Due to the unique nature of the EM-TV and the high loads imposed, modification of a manufacturer’s go-kart cannot be accepted. For safety, reliability, and liability, conversions are limited to racing go-karts. Refer to the E-Kart class specifications.

Use components provided in the EV Master Teaching Vehicle (EM-TV) kit to construct a vehicle (All specs. included)

All EM-TVs, regardless of approach used, will be inspected prior to any competition and must adhere to the following rules and specifications.

### **VEHICLE**

#### **1. Vehicle Type**

Vehicles shall match all the performance and dimensional specifications of each section of these specifications or shall be assembled from an EV Master Teaching Vehicle (EM-TV) kit (All specs. Included). As stated previously, conversions of manufactured go-karts does not comply with these specifications.

#### **2. Dimensions**

The vehicles shall not deviate from the stock measurements

Track – center-to-center of tire, front = 37” (95 cm)

Track – center-to-center of tire, rear = 39” (99 cm)

Overall length = 80” (203 cm)

Wheel base = 60” (152 cm)

Distance from pedals to seat back = 36” to 42” (91 to 107 cm), adjustable

Weight (minimum, with batteries, without driver) = 300 lb. (136 kg)

Following measurements are for reference and are based on standard 15 x 6.00-6 tires front and rear with 14.6” (37 cm) diameter.

Ground clearance (minimum) = 4” (10 cm)

Height – front bumper = 8.75” (22 cm)

Height – rear bumper = 12.5” (32 cm)

Height – center of steering wheel = 24” (61 cm)

Height – top of roll bar = 40” (102 cm)

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### 3. Minimum Ground Clearance

No part of the vehicle shall be less than 2" (5 cm) above the ground with all tires removed from rims (vehicle sitting on the rims).

### 4. Modifications

***All modifications must be designed with safety as the principal concern. Modifications must not interfere with safe operation, result in frame modifications, or pose a safety risk to other participants. All modifications must be described in writing by email to Luis Romo at [lromo@EVMaster.com](mailto:lromo@EVMaster.com). Modifications will be closely inspected during tech inspection. It will be the discretion of the EV Rally staff to accept or reject modifications. To avoid disqualifications due to non-compliant modifications, it is strongly suggested that you discuss your plans ahead of time. Prior to the rally, modifications will be treated in confidence.***

No modifications of the basic design and construction or substitution of components will be permitted except as listed here or by specific written permission from EV Rally staff following the procedure outlined above.

#### Drive system

- Single and dual motor drives are allowed
- Different motor and axle sprocket sizes may be used
- Regenerative or dynamic braking may be used
- Multi-speed gearing, transmissions, or torque converters may be used.
- Dual-speed switching is allowed

#### Tires

- Tire inflation pressures may be varied provided the manufacturer's maximum inflation pressure is not exceeded.
- Non-standard tires may be substituted – subject to speed, load-carrying, clearance, and design considerations.

#### Batteries

- Only commercially available rechargeable batteries shall be permitted. Batteries shall be "sealed" (valve-regulated) type. The propulsion battery pack voltage shall be a maximum of 48 volts nominal. Total maximum battery weight shall not exceed 100 pounds (45 kg).

#### Body

- Vehicle numbers at least 6 inches high and in a contrasting color shall be displayed on the seat back. It is preferred to also attach number plates or other vertical surfaces suitable for displaying vehicle numbers and sponsors' names on each side of the vehicle. (Consider numbers plates on the battery box lids.)
- Vehicles can be equipped with body panels or other vertical surfaces suitable for displaying vehicle numbers and sponsors' names on each side of the vehicle.
- Vehicles may be equipped with body shells provided that:
  - Sharp edges, corners, or protrusions that could cause injury are avoided.
  - Fins, spoilers, air dams, and other aerodynamic devices must comply with the vehicle dimension requirements and not present sharp edges that can be a hazard to drivers and crews.
  - Bodywork, including windscreens, fairings, and canopies must not interfere with driver egress or access to the battery disconnect switch.
  - The driver must be able to exit the vehicle unaided within 20 seconds.
  - The disconnect switch must be operable from outside the vehicle without the removal of any bodywork.

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### **SAFETY**

#### **1. Roll Cage**

The factory-supplied side bars, roll bar, and bumpers (or dimensional equivalent) must be in place. The roll bar must extend above the top of the driver's head and shall be wider than the driver's shoulders. Side bars, designed to provide side impact protection shall run the length of the vehicle at a height greater than the driver's legs. The side bars, roll bar, and vertical steering support post closest to the driver shall be padded with at least ½" thick foam.

#### **2. Fire Extinguisher**

Each pit crew shall have at the ready a 2 1/2 pound or larger dry chemical 1A, 10BC fire extinguisher with a positive indicator showing charge, during all vehicle operation and charging. It is not necessary for a fire extinguisher to be mounted on the vehicle.

#### **3. Driver's Seat**

A contoured, molded racing seat must be used. The seat shall be mounted on an operable, adjustable seat track to accommodate different size drivers. The seat shall be securely bolted to the seat tracks and seat supports.

#### **4. Safety Belts**

A two-inch wide seat belt with standard automotive quick-release buckle shall be installed in the vehicle with the ends anchored to the structural frame as designed.

#### **5. Steering Wheel**

A steering wheel with padded rim shall be used.

#### **6. Clothing**

It is recommended that drivers wear driving suits of fire resistant material that effectively covers the body from neck to ankles to wrists. If such clothing is unavailable, the driver must, as a minimum, be dressed in long sleeved upper body garment and full-legged lower body garment. The upper and lower body garments must meet and overlap. Gloves and shoes must also be worn.

#### **7. Helmet**

Each team shall supply their own driver's helmet with a Snell 90 or better rating. The helmet must be equipped with a face shield or separate goggles. A neck collar must be worn.

### **ELECTRICAL**

#### **1. Wiring**

All wiring shall be routed to ensure they do not contact moving chassis components. Wiring shall be secured to prevent movement and protected from abrasion.

#### **2. Cables**

Cables supplying the motor and controller with traction battery current must be a minimum #6 AWG multi-strand copper with an abrasion resistant insulating jacket.

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### 3. Wiring devices

All wiring connections, switches, terminal blocks, and connectors shall be designed for the full-rated current of the application (e.g. quick-disconnects used on battery cables shall be designed to handle the controller's maximum current draw.)

### 4. Shock Protection

All voltages greater than 14 volts shall be insulated and protected from incidental contact. No exposed propulsion battery voltages shall be permitted.

### 5. Safety Devices

The manual disconnect switch, speed-limiting governor with interchangeable plug, and main fuse must be installed and in proper working order. (It is not necessary to use a speed limiting resistor in the governor plug for competition.) Control circuit wiring should be separately fused with a fast-acting fuse rated for 5 amps or less.

### 6. Traction Battery Fuse

Batteries must be current-limited via a DC rated fuse (250-Amp maximum rating) placed halfway through the battery string such that it divides the pack Voltage in half.

### 7. Instrumentation

At a minimum, instrumentation shall include means of measuring battery pack Voltage and current while the vehicle is operating. Such instrumentation shall be visible to and operable by the driver. Additional gauges and instrumentation including data loggers and 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 or power relays should be enclosed.

### 9. Batteries

Batteries shall be commercially available rechargeable, "sealed" (valve-regulated) type. The propulsion battery pack voltage shall be a maximum of 48 volts nominal. Total maximum battery weight shall not exceed 100 pounds (45kg). It is recommended that batteries be placed in the vehicle to minimize polar and roll moments of inertia and provide even weight distribution front-to-rear and side-to-side. 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.

### 10. Battery Enclosure

Batteries shall be contained in the marine-type battery boxes as supplied with the kits. The cover shall be removable to allow access to the batteries and battery terminals. The battery boxes shall be secured to the vehicle frame and be of sufficient strength to retain batteries in the event of collision or roll-over. It is recommended that the batteries be secured inside the boxes to prevent shifting.

### 11. 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.

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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. 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.

Chargers shall be equipped with standard NEMA plug connectors suitable for the voltage and current requirements of the charger. The charger AC plug shall be NEMA 5-15P 120 Volts, 15 amps. The AC breaker feeding the receptacle will be 20 amps. The AC receptacle in the charging area will be a NEMA 5-15R. Current will be limited to 16 amps AC. Charging power shall 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. Off-board chargers: It is assumed that all EM-TVs will use off-board chargers. If an on-board charger is installed, refer to the EV Rally Vehicle Specifications for additional guidance.

Off-board charges shall have a utility ground connection to the charger shell. 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. Alligator clips or other temporary connections shall not be permitted.

4. 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.
2. Controller  
Controller shall be DC, pulse-width modulating type. Maximum current rating of 400 Amps at nominal 48 Volts DC input. The controller shall be equipped with a high-pedal disable interlock to prevent energizing the controller with the accelerator depressed or allowing reverse to be energized while the pedal is depressed. Controller bypass switches are not permitted.

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### 3. Accelerator Mechanism

The controller shall utilize a foot-operated, low-current accelerator position sensor designed to switch the controller off if the sensor shorts or a wire becomes disconnected. Accelerator mechanisms shall be free moving and shall return to the zero current position when released. At least one energy source (e.g. springs) shall be provided to return the accelerator to the zero current position.

## Mechanical

### 1. Fasteners

Fasteners for steering, drive, and brake components must use locking nuts, lock washers, or safety wires.

### 2. Accelerator Mechanism

Accelerator mechanisms shall be free moving and shall return to the zero current position when released.

### 3. Brakes

Vehicles must have fully functional dual band brakes operated by a foot pedal with mechanical linkages. All brake linkage connections shall be secured with cotter pins or safety wires.

### 4. Chain Guard

The chain guard(s) shall be in place during competition