

Guidelines for Converted Electric Vehicles

EV Conversion Division
Association for the Promotion of Electric Vehicles

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Converted electric vehicles and other automobiles to be driven on roads must have the structure and equipment conforming to the technical requirements specified in legislation related to the Road Transport Vehicle Act ^(Note). Requirements to which particular attention should be paid are specified in the Notice regarding the creation of the document entitled “Points to Keep in Mind for Electric Vehicle Conversion (EV conversion)” (issued by the Kanto District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism on September 29, 2010). However, the Notice does not fully cover all applicable requirements because converted electric vehicles greatly vary with regard to base vehicle structure, details of the conversion, and the parts used.

Converted electric vehicles must be made in compliance with the legislation related to the Road Transport Vehicle Act by referring to the Points to Keep in Mind for Electric Vehicle Conversion as mentioned above. To further ensure vehicle safety and reliability, it is necessary to assume that conversion is carried out as business involving the selling vehicles to an unspecified large number of users.

Based on this point of view, the Conversion Division has established the Guidelines for Converted Electric Vehicles (which is attached to this document). It covers extensive technical requirements, ranging from those that must be satisfied, to voluntary standards which should be satisfied. These Guidelines also stipulate precautions to take as needed when applying the requirements specified in the legislation related to the Road Transport Vehicle Act to converted electric vehicles to supplement the Points to Keep in Mind for Electric Vehicle Conversion described above.

The Conversion Division will continue to strive to ascertain the actual status with regard to converted electric vehicles, such as the technologies employed in them and how such vehicles are used, and will review these Guidelines as needed to respond to the actual status.

(Note) For details of the related legislation, refer to the following websites:

- Safety Standards for Road Transport Vehicles (Ordinance No. 67 of the Ministry of Transport enacted on July 28, 1951) and Notification of Details of Safety Standards for Road Transport Vehicles (Notification No. 619 to the Ministry of Land, Infrastructure, Transport and Tourism enacted on July 15, 2002):
http://www.mlit.go.jp/jidosha/kijyun/kokujitou_index.pdf
- Regulations regarding Paperwork to Be Examined, established by the National Agency of Vehicle Inspection
<http://www.navi.go.jp/images/info/pdf/Shinsajimukitei.pdf>

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Guidelines for Converted Electric Vehicles

Chapter 1 Scope

These Guidelines were established for electric vehicles converted from relatively small four-wheel vehicles equipped with manual transmission and that had been previously driven on roads (had once been assigned license plates). These Guidelines may be referred to for electric vehicles converted from other vehicles as well.

Provisions using “shall” indicate requirements to be satisfied and provisions using “should” indicate recommendations in these Guidelines.

Chapter 2 Definition of Terms

Definitions of terms used in these Guidelines are specified below and in legislation related to the Road Transport Vehicle Act, such as Attachment No. 110, Technical Standards for Protection of Passengers from High Voltages in Electric and Electric Hybrid Vehicles to the Notification of Details of Safety Standards for Road Transport Vehicles (Notification No. 619 to the MLIT enacted on July 15, 2002) (hereafter called the Notification of Details.)

- (1) *Vehicles made on or after yyyy* refer to vehicles shipped by automobile makers (automobile manufacturers) on or after yyyy. Generally, the year of the initial registration or initial inspection stated on each vehicle’s inspection certificate applies.
- (2) *EMC* refers to electromagnetic compatibility, or the ability of an electric device to function properly without causing any electromagnetic interference and without failing due to electromagnetic waves.
- (3) *ECE Rule No.* refers to the number of one of the rules established for safety of automobiles under the 1958 Agreement (Agreement concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts Which Can Be Fitted and/or Be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of These Prescriptions).
- (4) *WP29* refers to the World Forum for Harmonization of Vehicle Regulations, which was established within the United Nation Economic Commission for Europe for activities including the establishing of internationally harmonized standards for automobile safety

and environment and managing the 1958 Agreement and the 1998 Agreement (Agreement concerning the Establishing of Global Technical Regulations for Wheeled Vehicles, Equipment and Parts Which Can Be Fitted and/or be Used on Wheeled Vehicles).

- (5) *An accelerator* refers to a potentiometer operated from an accelerator pedal via a wire or other means.
- (6) *An accelerator position meter* refers to a potentiometer directly connected to an accelerator pedal.
- (7) *A speed controller* refers to a device that controls the rotation of a motor.
- (8) *A contactor* refers to a device (relay) that controls a large current by using a small current to protect a contact frequently switched under high current and other severe conditions.

Chapter 3 Technical Requirements for Structures and Devices

I General Electric Devices

1. Compliance with requirements specified for electric devices in the Notification of Details

- (1) Electric devices shall comply with requirements specified in Article 99.2 of the Notification of Details.
- (2) Electric devices shall comply with requirements specified Article 99.4 of the Notification of Details.

Explanation:

- Compliance with Articles 99.2 and 99.4 of the Notification of Details is essential for vehicles converted from those made in or after July 2012.
- Article 99.2 specifies the requirements for protection against electric shock caused by high-voltage circuits (including protection against direct and indirect contact), drive battery requirements (including the installation of protective devices against overcurrent and the method for installing open type drive batteries that generate hydrogen gas), the requirements for the indication of standby and operable states, and other requirements.

- Article 99.4 specifies requirements stating that a drive battery pack shall be installed in a specified position (at least 420 mm from the front edge of vehicle, at least 65 mm from the rear edge of vehicle, and at least 130 mm from the outermost side of vehicle) and that it shall be installed reliably so as to withstand vibration, impact, and other stresses.

2. Colors of electric cables

- (1) High-voltage cables, excluding those inside enclosures, shall be identified with orange external coating.

Explanation: This requirement was established in response to the requirement specified in Revision 01 series to ECE Rule No. 100 (Attachment No. 110 to the Notification of Details will soon be revised to reflect the revision of these Standards in Japan).

- (2) DC electric cables shall have red coating on the positive end and black coating on the negative end. High-voltage cables with orange coating may be marked in red and black at the ends of the orange coating.

3. Protection against electric shock in case of collision

Electric devices should have a mechanism that shuts off high-voltage circuits using inertia relays or the like in case of the vehicle is involved in a collision.

4. High-voltage shutoff system

- (1) Vehicles shall be equipped with a service plug that shuts off high voltage without the use of any tool in order to protect workers from electric shock during maintenance work.
- (2) If the installation of a service plug is impossible, the vehicle shall be equipped with a circuit breaker that shuts off high voltages without the use of any tool. The circuit breaker shall be structured so that the drive battery enclosure cannot be opened when the circuit breaker is ON and the circuit breaker cannot be turned ON when the drive battery enclosure is open.

5. Electromagnetic compatibility (EMC)

Electric devices, particularly, speed controllers, should be verified by their manufacturers regarding the electromagnetic compatibility in the environment where vehicles are used.

Explanation: Article 99.1 of the Notification of Details specifies the mandatory requirements that electric waves emitted from electric devices shall not disturb functions of radio equipment. In addition, electric devices should have immunity to electromagnetic waves to function properly. The requirement for electromagnetic compatibility is specified here and ECE Rule No. 10 will soon be added to the Notification of Details in order to specify concrete EMC testing methods.

6. Monitoring of insulation resistance

Electric devices should be equipped with detectors to monitor the insulation resistance between the live components and the electrical chassis.

II Drive Batteries

1. Drive battery safety

- (1) Drive batteries shall have a system to shut off the power supply when they are fully charged, in order to prevent overcharging.
- (2) Drive batteries shall have appropriate anti-heat radiation measures.

Explanation: There is an international movement toward further safety measures for drive batteries. For example, UN/ECE/WP29 is considering requirements for assurance of safety of lithium ion batteries. These Guidelines need to be reviewed in response to the changing situations.

2. Method of drive battery installation

The drive battery pack shall be installed as specified in I 1. (1) and (2) as specified below:

- (1) The drive battery pack shall be installed in such a way that the weight balance of the converted vehicle shall not exceed the weight balance of the base vehicle.
- (2) The drive battery pack shall satisfy the installation strength specified in Attachment No. 111 to the Notification of Details.

Explanation: Attachment No. 111 to the Notification of Details specifies the following requirements:

- The drive battery shall not rupture under acceleration in a direction in parallel with the vehicle center line of $\pm 196 \text{ m/s}^2$ (in the case of small cars).
- The drive battery shall not rupture under acceleration in a direction perpendicular to the vehicle center line of $\pm 78.4 \text{ m/s}^2$ (in the case of small cars).

3. Inspection of drive battery electrolyte

The enclosure, barrier or other casing of the drive battery shall be structured so as to facilitate maintenance in order that the electrolyte level and specific gravity can be checked at the intervals recommended by the manufacturers of the drive battery.

4. Drive battery life indicator

The driver's seat shall be equipped with an indicator to allow a driver to estimate the remaining life of the drive battery or remaining travel distance.

III Motors and Drive-trains

1. Strength of connection between motor and drive-train

- (1) The motor-transmission connection shall be via a metal plate of sufficient strength and made to a sufficient accuracy.
- (2) The motor shall be installed in such a way that motor rotations will not cause abnormal vibrations or damage the drive-train, including the transmission.

Explanation: The requirements specified in the safety standards state that the motor-transmission connection shall be rigid enough to withstand the running of the vehicle. Points to which particular attention should be paid with regard to converted electric vehicles are stated here as a supplement to that requirement.

2. Strength of drive-train

- (1) The maximum motor torque shall be within a range that ensures the strength of the drive-train. For example, when a converted vehicle uses the unmodified drive-train (including the transmission) of the base vehicle and the maximum motor torque does not exceed the maximum engine torque of the base vehicle, the motor shall be considered to comply with this requirement.
- (2) If the maximum motor torque can be easily changed, for example, by setting a controller, to a value exceeding the motor installation strength or the drive-train strength, such simple changes shall be prevented by taking appropriate measures, for example, by sealing the motor.

Explanation: The requirements specified in the safety standards state that the drive-train shall be rigid. Points to which particular attention should be paid for converted electric vehicles are stated here as supplementary requirements.

3. Motor fixing method

The motor shall be installed in a way to ensure a strength equivalent to the strength of existing engine mount. When a converted vehicle uses the engine mount of a base vehicle without any modification and the weight and maximum torque of its motor does not exceed the weight and maximum torque of the engine of the base vehicle, the motor shall be considered to comply with this requirement.

Explanation: The requirements specified in the safety standards state that the motor shall be installed in a rigid way. A point to which particular attention should be paid with regard to converted electric vehicles is stated here as a supplementary requirement.

4. Waterproof measures for high-voltage motor controller

- (1) In cases where the motor is not waterproof, measures shall be taken to equip it so that water is prevented from splashing while the vehicle is running in the rain or when it is being washed.
- (2) Parts, wires, and other components of the motor circuits shall be waterproof.
- (3) Stringent waterproofing measures shall be taken during accelerator installation, for example, installing it inside the passenger compartment or putting it in a waterproof box installed in a position inside the engine room where it is unlikely to be splashed by water.

5. Wires to the motor

- (1) To prevent wires and terminals from burning, electric cables suitable for the amount of current shall be used. In particular, wires used for circuits that connects the drive battery to the motor shall be able withstand the maximum driving current.
- (2) Wires and terminals shall be strong enough to withstand the operating environment of the vehicle.

6. Water resistance of in-wheel motors

In-wheel motors shall cause no electric leakage, failures or other problems in the normal operating environment.

Explanation: The requirements specified by Article 88.1 of the Notification of Details state that the motor shall fully withstand the running of the vehicle. A point to which particular attention should be paid for converted electric vehicles is stated here as a supplementary requirement.

7. Vehicle running performance

Converted vehicles shall satisfy the following conditions depending on their classification:

Ordinary vehicles: GVW (Gross vehicle weight) $\leq 135 \times$ kW (Maximum output) – 1500

Small vehicles and light motor vehicles: GVW (Gross vehicle weight) $\leq 122 \times \text{kW}$
(Maximum output) – 600

8. Method for confirming maximum output, rated output, and maximum torque

The maximum output, rated output, and maximum torque values may be derived from performance curves or specifications provided by motor manufacturers or other parties or from nameplates or other labels attached to motors.

IV Speed Controllers and Accelerators

1. Failsafe functions and other functions for speed controllers and the like

- (1) To ensure stable performance, appropriate heat radiation measures to prevent damage caused by heat shall be taken for the speed controller and other similar devices (hereafter called “the speed controller or the like”).
- (2) If any abnormality occurs regarding the speed controller or the like, such as an abnormal temperature rise, the driver sitting in the driving seat shall be alerted.
- (3) The speed controller or the like should be designed so as to not allow unintended accelerations and to not hinder the driver’s intended deceleration in cases of abnormality, disconnection or short circuit affecting the accelerator signal input line, or in cases where the accelerator or throttle position meter is disconnected, short circuited or gets stuck.

Explanation:

- These standards require devices to work properly in cases of abnormality. For example, speed controllers are required to detect the occurrence of abnormality and block the base (i.e. shut off the power supply and the regeneration) and allow free running, and mechanical braking systems are required to maintain their function in cases of abnormality.
- We will consider establishing requirements for brake override systems in response to changing situations.

2. Throttle safety

- (1) If the accelerator is used for motor rotation control, it shall have double return springs in order that its operation will be cancelled when a driver is not operating the accelerator pedal.
- (2) The accelerator shall be smoothly actuated by operation of the accelerator pedal, and the return springs of the accelerator pedal and accelerator shall have sufficient return strength.
- (3) If an accelerator position sensor directly connected to the accelerator pedal is used for motor rotation control, it shall have double return springs in order that its operation will be cancelled when a driver is not operating the accelerator pedal.

Explanation: The safety standards require the installation of double accelerator return springs. Points to which particular attention should be paid for converted electric vehicles are stated in (1) and (3) as supplementary requirements.

3. Installation of contactors

- (1) A contactor shall be installed between the drive battery and the speed controller, and it shall fully withstand frequent switching under severe conditions.
- (2) The contactor shall have a rating higher than the maximum current of the speed controller and also higher than ratings of high-voltage circuit protective devices, such as fuses and circuit breakers.

V DC/DC Converters and In-vehicle Battery Chargers

1. DC/DC converters

- (1) Appropriate measures shall be taken to prevent a vehicle from running when lights or other auxiliary equipment is inoperable and to prevent such equipment from becoming inoperable when the vehicle becomes unable to run due to a voltage drop of the drive battery or for another reason. One example is equipping the vehicle with auxiliary equipment batteries powered from a DC/DC converter. The auxiliary equipment batteries may also be powered by solar cells.

- (2) A vehicle with no auxiliary equipment batteries shall have a DC/DC converter with regard to which the output current can withstand the maximum power consumption of the auxiliary equipment being used.

2. In-vehicle battery chargers

- (1) The in-vehicle battery charger shall be designed to stop power supply when the drive battery is fully charged.
- (2) The in-vehicle battery shall not shorten the travel distance or adversely affect the service life of the drive battery.
- (3) The in-vehicle battery shall comply with specifications required by drive battery manufacturers and others.

VI Brakes

1. Alternative devices, such as servo brake systems (changing the negative-pressure source and the air source)

- (1) If an electric vehicle is converted from a base vehicle that is equipped with a servo brake system using engine negative pressure, the electric vehicle shall be equipped with an electric negative-pressure pump or the like to ensure braking assistance equivalent to the original brakes of the base vehicle.
- (2) An alert system shall be mounted on the driver's seat to indicate any failure of the electric negative-pressure pump or other assistance device (including the loss of negative pressure).

2. Installation of electric regeneration brakes

- (1) An electric regeneration brake should be mounted as an alternative to engine braking.
- (2) The electric regeneration brake should be operable even if the drive battery is fully charged.

Explanation: If the vehicle has no electric regeneration brake, the person in charge of converting the vehicle shall be responsible for ensuring the safety of the vehicle.

VII Prevention of Sudden Starting due to Incorrect Operation

A vehicle shall have a system that shows the driver the standby or operable state according to the requirement in I 1. (1). Measures shall be taken to prevent sudden starting and other accidents due to incorrect operation in accordance with the following requirements.

- (1) With regard to operations for the switching of a vehicle into an operable state, there should be measures to ensure safety when a vehicle starts moving.

Explanation: Today manual transmission vehicles have a mechanism (clutch start system) that allows the engine to start only when the clutch pedal is pressed down. Automatic transmission vehicles have a key interlock function that allows the ignition key to be pulled out only when the shift lever is in Park and a shift lock function that allows the shift lever to be moved from Park only when the brake pedal is pressed down. Converted electric vehicles shall have appropriate measures created in reference to these functions. One possible example is to equip electric vehicles converted from manual transmission vehicles with a system that prevents ignition from turning on when the accelerator pedal is pressed or allows the shift lever from being moved from the Park range for creeping only when the brake pedal is pressed.

- (2) The state of running direction control unit should be able to be identified by a driver.

Explanation: This requirement is based on the requirements specified in Revision 01 series to ECE Rule No. 100 (Attachment No. 110 to the Notification of Details will soon be revised in Japan to reflect this revision). This requirement specifies that there be an indication on the instrument panel, independently of the gearbox indication specified in the Notification of Details under Article 10 of the existing safety standards.

- (3) When the running direction control unit is in the reverse position, this state shall be notified to a driver by using a buzzer or other means. If such a function is not provided for the base vehicle, it should be added to the vehicle.
- (4) The reverse speed shall be adequately restricted.
- (5) A vehicle with no gearbox should be designed to allow the shift lever to be moved from Drive to Reverse and vice versa only when the accelerator pedal is not pressed and the brake pedal is pressed.

- (6) When the vehicle has a creep mechanism, creeping shall be controlled properly.

Explanation: Properly controlled creeping contributes to convenience and safety at the time of hill starting or when parking in a garage. It has another advantage that when the brake pedal pressing force is reduced and the shift lever position differs from that intended by the driver (for example, when the driver thinks the shift lever is in Neutral but it is actually in Drive), the driver can recognize the misunderstanding without pressing the accelerator pedal. However, further consideration is required as to whether this function is required.

- (7) The requirement in I 1. (1) specifies that a vehicle should be equipped with a device that indicates to a driver that the vehicle is in a standby or operable state. This “indication” shall be a visual indication that is sufficient to enable a driver to be aware that the vehicle is in said state. In addition, if a vehicle is still in an operable state when a driver leaves it, an alert signal (such as an optical or audio signal) should be given to the driver.

Explanation: The latter part of this requirement is specified in ECE Rule No. 100.

- (8) An alert should be issued when the ignition key is pulled out without the parking brake having been operated first.
- (9) A device that indicates that charging is in progress should be mounted on the driver’s seat side.
- (10) A vehicle shall be structured to be kept inoperable during charging from a fixed power supply.

Explanation: This requirement is based on the requirement specified in Revision 01 series to ECE Rule No. 100 (Attachment No. 110 to the Notification of Details will soon be revised in Japan to reflect this revision).

VIII Other Devices

1. Alternatives to power steering pumps

- (1) When an electric vehicle is converted from a base vehicle equipped with electric power steering, the control force of the converted electric vehicle shall be equivalent to that of the base vehicle.
- (2) When an electric vehicle is converted from a base vehicle equipped with hydraulic power steering, the elimination of the power steering function is unavoidable. However, the converted electric vehicle should have a control force equivalent to that of the base vehicle, for example, by the installation of an electrically actuated hydraulic pump.

2. Alternatives to defrosters

The defroster of a converted electric vehicle shall have a performance equivalent to that of the base vehicle.

3. Vehicle proximity warning devices

Converted electric vehicles should be equipped with a vehicle proximity warning device as specified in the Guidelines for Measures for Hybrid and Other Quiet Vehicles, the attachment to the Notification of the Guidelines for Measures for Hybrid and Other Quiet Vehicles (Announcement No. 255 of Engineering and Safety Department, Road Transport Bureau, MLIT, issued on January 29, 2010).

Chapter 4 Attached Sheets for Notification of Conversion

It is necessary to notify district transport bureau branches (regional offices of the Light Motor Vehicle Inspection Organization for light motor vehicles, or main branch offices of the National Agency of Vehicle Inspection for other types of vehicles) in advance of the conversion of a vehicle. For notification, the following documents shall be submitted:

- List of electric devices (Attached Format 1)
- A sheet describing considerations with regard to compliance with technical standards related to protection against electric shock (Attached Format 2)

- A calculation sheet for the strength of the drive battery pack mounting (Attached Format 3)
- A sheet describing considerations with regard to compliance with EV conversion structure standards and a check sheet of measures against electric shock taken for electrically live components
- Drawings of high-voltage circuits
- Data that identifies the motor model and data that identifies the maximum output (rotation speed), the rated output (rotation speed), and the maximum torque (rotation speed) of the vehicle to be converted (Examples are performance curves and specifications provided by motor manufacturers or other parties, and nameplates and other labels attached to motors.)
- Calculation sheet for motor mounting strength for a vehicle whose motor weight or maximum torque exceeds the engine weight or maximum torque or for a vehicle which does not directly use the engine mount of the base vehicle
- Drawings showing dimensions of connecting flanges and other parts for the connection between the motor and the transmission, calculation sheet for connection strength, and other documents

Chapter 5 Responsibilities of Vehicle Conversion Shops

- (1) Vehicle conversion shops shall prepare the following documents and provide them to vehicle users to ensure the proper maintenance, management, and use of converted electric vehicles.
 - Documents describing details of the conversion
 - Lists of devices and parts added
 - Inspection and maintenance manuals (describing the maintenance of parts, drive battery replacement procedures, etc.)
 - Circuit diagrams
 - Documents giving precautions regarding the driving of a converted electric vehicle
- (2) When selling converted electric vehicles, vehicle conversion shops shall fully explain to users about the use, maintenance, and management of the converted electric vehicles.
- (3) Vehicle conversion shops shall provide users with full information about the drive battery, motor, and other parts added for conversion with clear instructions with regard to

required inspection cycles, items, and methods, based on information provided by the manufacturers or vendors of the parts.

- (4) Vehicle conversion shops shall provide users with full information about charging equipment and charging methods by referring to the Guidebook for Installing Charging Equipment for Electric Vehicles and Plug-in Hybrid Vehicles (METI and MLIT, December 2010).

Supplementary provision

These Guidelines shall come into force on May 1, 2011.