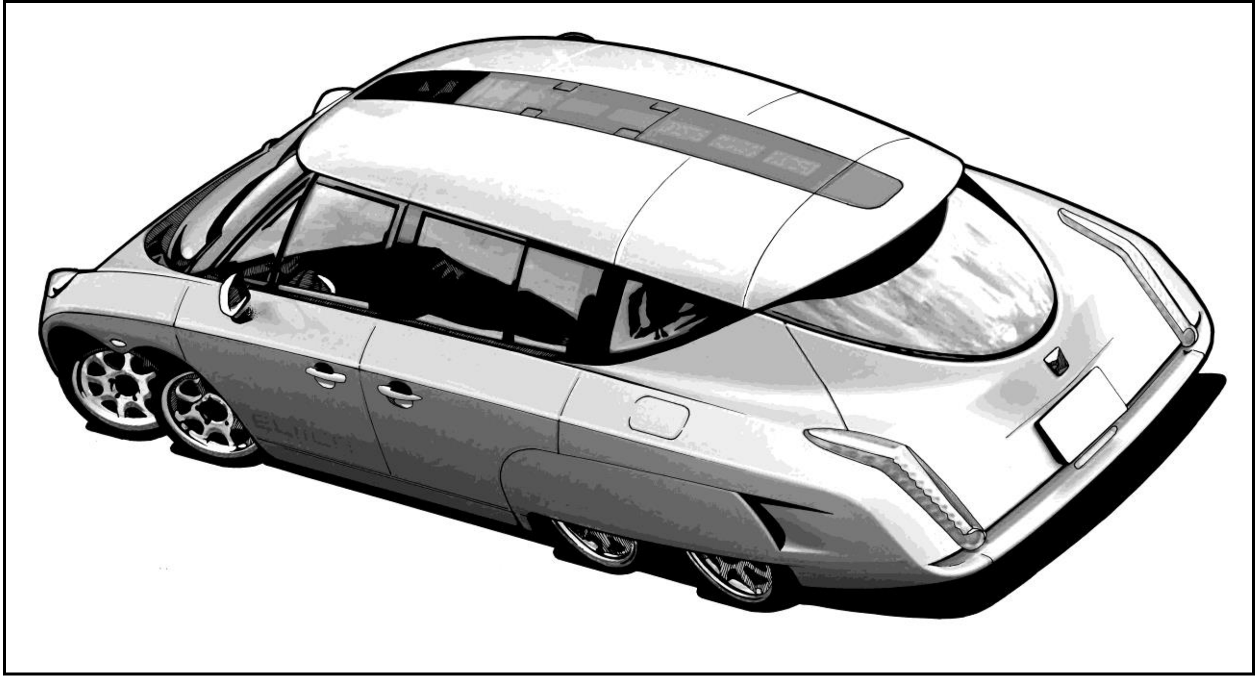
Low Volume Vehicle Technical Association Incorporated

Low Volume Vehicle Standard

75-00(02)

(Electric and Hybrid Vehicles)

This Low Volume Vehicle standard corresponds with Land Transport Rule: Vehicle Standards Compliance 2002, and Land Transport Rule: Light Vehicle Brakes 2002



2nd Amendment - effective from: 1 November 2018

Signed in accordance with clause 1.5 of the Low Volume Vehicle Code, on……………………………………………………..by:	
on behalf of the New Zealand Transport Agency: ……………………………………………………………………………………………	*on behalf on the Low Volume Vehicle Technical Association (Inc):* ……………………………………………………………………………………………

LVV Standard 75-00 Amendment Record:

No:	Detail of amendments:	Issue date:	Effect date:	LVV Code ref. #:
1	(00) Initial release	1 December 2011	1 May 2012	Annex 1, LVV Code Issue 7
2	(01) 1st Amendment	1 June 2013	1 July 2013	Annex 1, LVV Code Issue 8
3	(02) 2nd Amendment	1 November 2018	1 November 2018	Annex 1, LVV Code Issue 12
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Note that highlighted text shows amendments that have been made subsequent to the document's previous issue, and a grey vertical stroke to the left of the text denotes information that is of a technical (rather than a formatting) nature.

Overview

Background

The Low Volume Vehicle Technical Association Incorporated (LVVTA) represents nine specialist automotive groups who are dedicated to ensuring that vehicles, when scratch-built or modified, meet the highest practicable safety standards. The information in these standards has stemmed from work undertaken by LVVTA founding member organisations that commenced prior to 1990 and has been progressively developed as an integral part of NZ Government safety rules and regulations by agreement and in consultation with the New Zealand Transport Agency.

As a result, the considerable experience in applied safety engineering built up by LVVTA and the specialist automotive groups during the past three decades can be of benefit to members of the New Zealand public who also wish to build or modify light motor vehicles.

Availability of low volume vehicle standards

Low volume vehicle standards are developed by the LVVTA, in consultation with the New Zealand Transport Agency, and are printed and distributed by the LVVTA. The standards are available to the public free of charge from the LVVTA website; www.lvvta.org.nz

Further information on the availability of the low volume vehicle standards may be obtained by contacting the LVVTA at info@lvvta.org.nz.

Copyright

Associated information

Other associated information relevant to the subject matter contained in this low volume vehicle standard, which in the interest of comprehensiveness, should be read in conjunction with this standard, includes:

Document	Page #/Section/Chapter
• LVV Information Sheet # 10-2011	Release of Electric & Hybrid Vehicle Standard
• LVVTA News June-September 2013 Issue 47	Page 10 No EV Form-set For Now
• LVVTA News July-December 2017 Issue 54	Page 5 Gross Vehicle Mass Correction Process

Note that all documents referred to in this table, with the exception of the NZ Car Construction Manual, can be accessed from www.lvvta.org.nz free of charge. For information on obtaining the NZ Car Construction Manual, contact info@lvvta.org.nz

Note also that paper copies of documents can become out of date and as such should not be relied upon, therefore LVVTA advises users of this standard to check to ensure that the Associated Information listed here is current, by going to www.lvvta.org.nz/standards.html

Contents

Electric and Hybrid Vehicles (75-00[02])

Purpose of this standard

The purpose of this low volume vehicle standard is to specify requirements for light motor vehicles that are converted to electric or hybrid propulsion, or that are scratch-built using electric or hybrid propulsion, which must be met, in order to ensure that the vehicles are safe during all conditions, in relation to their electrical systems, and also in relation to any inter-related effects that the electric or hybrid systems might have on other safety-related systems within the vehicle, particularly those governing directional and braking control.

Section 1 Scope and application of this standard

1.1 Scope of this standard

1.1(1) For the purposes of this low volume vehicle standard, a vehicle will be referred to as an electrically-powered vehicle if:

(a) a vehicle has been converted to electric or hybrid power; or

(b) a vehicle has been scratch-built using electric or hybrid power; or

(c) modifications have been made to a vehicle's electric or hybrid power systems.

NOTE 1: *1.1(1)(c)* includes modifications that may affect vehicle safety, such as the addition of a plug-in charging system, an on-board charging system, additional batteries, or changes to battery chemistry or battery location.

NOTE 2: This standard is aimed at systems such as single or multiple electric traction motors, alternative non-electric drive-line power units, charging generators, storage batteries, other electric power sources such as solar cells, and on-board mains chargers. Technically-advanced systems such as fuel cells can have wider implications on safety and are outside of the scope of this standard.

Refer to LVVTA for individual advice on certification of fuel cells and other similarly-complex systems.

1.1(2) An electrically-powered vehicle that has been converted, scratch-built, or modified as in *1.1(1)* in New Zealand on or after 1 January 1992, or outside New Zealand on any date, must be certified to the Low Volume Vehicle Code in accordance with the application requirements specified in *1.2*.

NOTE 1: An electrically-powered vehicle that has been converted, scratch-built, or modified outside of New Zealand must be certified to the Low Volume Vehicle Code, regardless of the date of conversion, build, or modification.

NOTE 2:	The requirement for LVV certification in the case of electric or hybrid systems was triggered by the introduction of the *Transport (Vehicle Standards) Regulations 1990* which, for low volume vehicles, took effect on 1 January 1992. Because electric or hybrid power may have an effect on the performance of a vehicle's braking system, and *Transport (VS) Regulation 1990: (13) Brakes* took effect on 1 January 1992, this date becomes the application date of this low volume vehicle standard.

1.2 Application of this standard

1.2(1) An electrically-powered vehicle, other than one specified in *1.2(3)*, that has been converted, scratch-built, or modified as in *1.1(1)* between 1 January 1992 and 1 May 2012 becomes a low volume vehicle, and must:

(a) be certified in accordance with the procedures specified in *chapter 2* of the *Low Volume Vehicle Code*; and

(b) comply with the general safety requirements specified in *2.1* of this standard.

NOTE:	In order to assess whether or not the general safety requirements contained in *2.1* of this standard have been met, an LVV Certifier may use the applicable technical requirements of *section 2* of this standard as a guideline upon which to base his judgements.

1.2(2) An electrically-powered vehicle, other than one specified in *1.2(3)*, that has been converted, scratch-built, or modified as in *1.1(1)* on or after 1 May 2012 becomes a low volume vehicle, and must:

(a) be certified in accordance with the procedures specified in *chapter 2* of the *Low Volume Vehicle Code*; and

(b) unless *section 3* applies, comply with all applicable technical requirements contained in *section 2* of this standard.

NOTE:	The reference to 'applicable technical requirements' in *1.2(2)(b)* is of particular relevance to a low volume vehicle to which an unmodified electrically-powered drive-train from a production vehicle is converted. Such a low volume vehicle must comply only with those applicable technical requirements contained in *section 2* of this standard which relate to the components and systems that are not part of the converted production vehicle drive-train.

1.2(3) This low volume vehicle standard does not apply to:

(a) powered bicycles of Class AB; or

(b) mopeds of Class LA, LB; or

(c) light trailers of Class TA or TB; or

(d) those vehicles specified in *section 4*.

Section 2 Technical requirements of this standard

2.1 General safety requirements

General operational safety

2.1(1) A low volume vehicle must:

(a) be designed and constructed using materials and components that are fit for their purpose; and

(b) be safe to be operated on the road.

NOTE: The requirements specified in *2.1(1)* are selected from *2.3* of *Part 2* of the *Low Volume Vehicle Code*, reproduced here in the interest of convenience, and are over-riding requirements which make it clear that, regardless of what technical requirements are or are not in place within this standard, every vehicle certified to the *Low Volume Vehicle Code* must be fit for its intended purpose, and must be safe.

Tradesman-like manner

2.1(2) Any electrical, mechanical, engineering, or fabrication work associated with a modification or construction feature in a low volume vehicle must:

(a) be carried out in a thorough, tidy, and tradesman-like manner; and

(b) follow sound electrical and automotive engineering principles.

NOTE 1: *2.1(2)(a)* specifies that it is an expectation of the LVV certification system that modification work is not only compliant and safe, but is carried out to a reasonable standard. Engineering work that - whilst compliant and safe - has been executed in a manner that makes the job rough or crude in appearance, can bring the LVV certification system into disrepute through observers' perception (rightly or wrongly) of any such work. This in turn can lead to complaint investigations being raised, which can consume time unnecessarily.

NOTE 2: 'Automotive engineering principles' referred to in *2.1(2)(b)* is intended to mean those top-end quality engineering principles employed throughout the light passenger vehicle manufacturing industry, and not low-technology industrial equipment such as some fork-lifts.

2.2 Electrical systems

General system requirements

2.2(1) The electrical system within an electrically-powered low volume vehicle must incorporate:

(a) design features that, in the event of a common malfunction, provide a fail-safe outcome; and

(b) fail-safe measures such as fuses, circuit-breakers or fusible links that offer adequate protection in case of a short-circuit, which must be appropriate for the voltage and have a current-carrying capacity less than that of the wiring, main contactors, and switches; and

(c) a master isolation switch within reach of the driver in the normal seated position that cuts off motive power immediately by isolating all poles of the motor power supply from the motor controller circuitry, either mechanically or electro-mechanically; and

(d) a separate battery or electrical supply management system that provides priority to the power supply needs of the vehicle's safety equipment, such as lighting equipment, brakes, and windscreen wipers; and

(e) a suitable mechanical maintenance isolation switch, operated without the need for tools, close to each separate group of batteries, to isolate all poles of the batteries such that safe access is provided for maintenance within two minutes of power disconnection; and

(f) components that are able to operate effectively while subject to typical vehicle operation conditions, such as vibration, and dust and moisture ingress, without leading to fatigue and premature failure; and

(g) clearly-visible labels warning of electric shock hazards, as specified in *2.6(1)*, on the exterior of the vehicle, and on the covers of all compartments which contain high voltage connections; and

(h) an inertia switch to automatically disconnect the battery in the event of a vehicle crash.

NOTE 1: Inspecting and maintaining an electric vehicle can be extremely hazardous due to the high voltages present. Within the context of this standard, 'high-voltage' is defined as exceeding 60V DC or 25V AC. All work must be carried out with a high regard for personal safety, using appropriate tools and all available safeguards

NOTE 2: Fuses, switches, contactors, and wire insulation as referred to in *2.2(1)(b)* must be appropriate for the voltages and current type present in the system. For example:

- use of an automotive blade fuse on a high-voltage circuit could result in a fire if the fuse opens;
- cylindrical glass fuses commonly available are mostly rated for 240v AC, which is quite different from a DC rating and may explode or fail to open circuit if used with high-voltage DC;
- fuses with appropriate ratings are usually ceramic or fibreglass bodied with a sand filling;
- DC contactors often have 'blow-out' magnets which blow the arc out of the contactor, improving their ability to clear a high voltage current. Such contactors must not be installed backwards, as the magnets will blow the arc into the contactor and reduce their voltage rating.

NOTE 3: All connections to the high-voltage system as referred to in *2.2(1)(b)* should be fused as closely as practical to the battery, including small wires such as sensor-wires on a current shunt or volt-meter.

NOTE 4: The master isolation switch referred to in *2.2(1)(c)* can be an electro-mechanical switch, such as a solenoid cut-out operated by an automotive ignition switch, although this may not provide full disconnection in the event of an electrical malfunction. The master isolation switch should ideally be mechanical only, to physically disconnect power.

NOTE 5: To assist emergency services personnel or other people that may be unfamiliar with the layout of the modifications, all efforts should be made to place any isolation switches in accessible locations and to clearly identify them.

NOTE 6: The maintenance isolation switch referred to in *2.2(1)(e)* must be suitable for disengaging both poles of a high-voltage high-current supply, such as an Anderson connector. A cut-off switch such as those used in motorsport applications is not suitable as it is not suitably rated and disconnects one pole only. It is recommended that access to high-voltage components is prevented until the isolation switch has disengaged the supply.

NOTE 7: The electrical system may retain energy in some components even after the isolation switch referred to in *2.2(1)(e)* has been disconnected. The system must be designed to deplete the energy within a period of two minutes so that maintenance work can be undertaken on the vehicle safely.

NOTE 8: In the case of a motorcycle, the master isolation switch referred to in *2.2(1)(c)* can be of a single-pole type, however the maintenance isolation switch referred to in *2.2(1)(e)* must disengage both poles.

NOTE 9: Batteries, as referred to in *2.2(1)(e)*, are considered to be in one group if they are located in a single container, or in more than one container that are situated in close proximity, less than 300mm apart. Note also that the other requirements for main battery pack isolation apply regardless of group isolation.

NOTE 10: Regarding *2.2(1)(e)*, the removal of any link or links in order to isolate batteries must not cause damage to the Battery Management System (BMS) if fitted, and any BMS wiring must not form an alternative current path when the link or links are removed.

2.2(2) The electrical system within an electrically-powered low volume vehicle must be designed to, or incorporate cooling to, maintain operating temperatures during prolonged operation in all typical ambient temperatures that are within the manufacturers' guidelines for all components and systems used within the vehicle's electric power systems.

NOTE 1: Typical New Zealand ambient operating temperatures, as referred to in *2.2(2),* range from -10 °C to +40 °C.

NOTE 2: Temperature monitoring should be considered for components that may be susceptible to heat or are placed in a vulnerable position.

Wiring requirements

2.2(3) The high-voltage (exceeding 60V DC or 25V AC) electrical wiring within an electrically-powered low volume vehicle must:

(a) be adequately insulated, taking into consideration the system's operating voltage and temperature range; and

(b) not be electrically connected to the vehicle's chassis or body; and

(c) be effectively sealed or otherwise resistant to the intrusion of dust and moisture; and

(d) be contained within a sealed, rigid protective housing where the wiring passes through the passenger compartment or load space; and

(e) be sized to make allowance for high peak currents in the case of stall, high regenerative braking, or high acceleration, of at least 1.5 times the continuous current rating of the motor or controller; and

(f) be adequately supported and secured to the chassis or other structural section at intervals of less than 350 mm; and

(g) be positioned against the chassis or other structural section in such a way that it is protected from accidental damage as a result of jacking or road debris; and

(h) have electrical connections with large voltage differences and high current capabilities positioned apart, so as to minimise the likelihood of short-circuits; and

(i) unless in an enclosed compartment, have protective covers over any live connections including any terminals; and

(j) allow for movement under high electrical, vibration, or thermal load; and

(k) be adequately protected where it passes through a bulkhead; and

(l) have electrical end-connectors effectively crimped to the cable, and not soldered; and

(m) have electrical cables with large voltage differences positioned apart, so as to minimise the potential for short-circuits or over-heating; and

(n) not be positioned within the roof, body pillars or outer sills; and

(o) not incorporate sharp bends.

NOTE 1:	'High-voltage', as referred to in *2.2(3)*, is defined for the purpose of this standard, as exceeding 60V DC or 25V AC.
NOTE 2:	*2.2(3)(a)* refers to the operating temperature range. Sensors can be used to monitor areas of highest temperature.

NOTE 3:	The requirement for sealing of cable housing in *2.2(3)(d)* is necessary to prevent noxious gases from entering the passenger compartment following a wire-short, arc and overheat situation.
NOTE 4:	The requirement for prohibited cable positioning in *2.2(3)(n)* is to prevent installation of high voltage cables in areas that emergency services commonly cut open as part of their rescue operation. Cables should ideally run down the centre of the vehicle, away from any common cut points.
NOTE 4:	High-voltage cables, as referred to in *2.2(3)(m),* must not be run in the same conduit and should be separated by approximately 150 mm, to avoid both cables being cut or damaged at the same time.
NOTE 5:	High-voltage cables or components should not be fitted to motorcycle handlebars.

2.2(4) The electrical wiring within an electrically-powered low volume vehicle that carries high current loads and/or high-voltage, must be orange in colour, and where the wiring is concealed in conduit, the conduit must be orange in colour.

NOTE:	Where high-voltage cables need to be marked with polarity or other designations, this should be done with a tracer colour along the orange cable length, or with coloured bands at the ends of the orange cable.

Overload protection

2.2(5) The electrical systems within an electrically-powered low volume vehicle must have over-current protection devices that:

(a) are an appropriate selection for the design of the electrical system; and

(b) are mounted as closely as possible to both poles of the power source, but not within a compartment containing venting batteries; and

(c) are designed to protect the wiring and electrical components of the electrical drive from over-heating following an over-current situation; and

(d) have between 20% and 40% overload capacity, in order to protect the electrical wiring and components of the electrical drive from damage; and

(e) are DC-rated for the maximum battery voltage and capable of interrupting the maximum short circuit battery current; and

(f) protect all connections to the high-voltage traction battery and motor wiring, which must include ammeter shunt wiring, volt meter wiring, battery management systems, chargers, and heaters; and

(g) in the event of deployment, are not likely to cause themselves, or any surrounding components to ignite.

NOTE 1: LVVTA recommends that:

(a) the electrical system is designed in such a way to ensure that a total loss of control to the traction motor cannot occur; and

(b) cable sizing takes into account any routing through confined areas which may limit effective cooling.

NOTE 2: Regarding *2.2(5)(a)*, a circuit-breaker, current-sensitive overload-relay or controller, has the advantage that it can be reset after a trip, but it provides less protection because it blows slower than a simple wire or cartridge-type fuse. LVVTA recommends that fuses are also installed to provide a faster disconnection of the power supply.

NOTE 3: Regarding *2.2(5)(f)*, this means that both the positive and negative connections to the battery pack require overload protection. Battery packs arranged in parallel must be individually protected.

External charging circuits

2.2(6) The electrical charging system of an electrically-powered low volume vehicle, that takes power from an external source, must:

(a) be fitted with an interlock which immobilises the vehicle when the charging cable is connected, regardless of the presence of a charging voltage; and

(b) have a cable and plugs appropriate to the charger specification; and

(c) be fitted with an internationally-accepted charging port with a water-tight lid or a male connection on the vehicle, which must not be live until the external charging cable is fully attached; and

(d) not be installed inside a compartment with venting type batteries; and

(e) if 230-volt domestic power or 3-phase supply is directly connected, any vehicle-related charging equipment is accompanied by either:

(i) a Certificate of Compliance, provided by a registered electrician to confirm that the wiring complies with the *Australia/New Zealand Wiring Standard AS/NZS 3001:2008 - Electrical installations – Transportable Structures & Vehicles including their site supplies*; or

(ii) an Electrical Safety Certificate such as a Test and Tag Appliance Type-certificate, undertaken by someone deemed competent by training or experience in accordance with *Australia/New Zealand Wiring Standard AS/NZS 3760:2010 - In-service Safety Inspection & Testing of Electrical Equipment.*

NOTE 1: The battery charging process has a high safety risk from a malfunction. Modern non-venting batteries can still overheat, emit noxious gases, and catch fire.

NOTE 2:	Common household wiring is rated at 15 amps but standard plugs are only rated at 10 amps. Plugs and sockets rated to 15 amps are available. LVVTA recommends that users follow EECA/MED guidance for charging needs over 10 amps.
NOTE 3:	Systems should not have exposed live connectors at any time; - a micro-switch can be installed on the fuel flap as an interlock to prevent the male vehicle connector being live and accessible. For safety during operation, a failure of such a micro-switch should not result in a loss of motive power.
NOTE 4:	An internationally-accepted charging port, as referred to in *2.2(6)(e)(ii)*, would meet an accepted standard such as J1772 32A.

2.3 Batteries

Battery restraint

2.3(1) Batteries used to power an electrically-powered low volume vehicle must be securely fixed in position by a support or restraint system constructed of durable materials that:

(a) for batteries located rearward of, inside, or under the passenger compartment, is able to withstand:

(i) in the forward longitudinal direction, 20 times the combined weight of the battery and restraint system; and

(ii) in all other directions, 2.5 times the combined weight of the battery and restraint system;

and

(b) for batteries located forward of the passenger compartment, is able to withstand in all directions, 2.5 times the combined weight of the battery and restraint system.

NOTE 1:	The loadings in *2.3(1)* are specified in order to ensure that the very high battery weights are adequately restrained in the event of a crash.
NOTE 2:	The strength of a battery compartment cover and fixings, or a bulkhead that is inter-positioned between any batteries and the passenger compartment, may be taken into consideration when assessing the strength of a battery restraint system.
NOTE 3:	Where lead-acid batteries or other devices are used that have the potential to release corrosive by-products, the selection of materials used in the battery restraint system should consider the need for the restraint system to be resistant to degradation in the presence of corrosive materials.

Battery compartments and venting

2.3(2) Batteries that are used to power an electrically-powered low volume vehicle, and which have the potential to emit a hazardous liquid or gas, must be effectively sealed off from the passenger compartment so that liquid spillage or gas leakage cannot occur, by either:

(a) individually sealing the batteries, and externally venting each battery; or

(b) fully enclosing the batteries within one or more sealed battery compartments, and externally-venting the compartments; or

(c) positioning the batteries outside of, and away from the passenger compartment, such as in a utility tray.

NOTE 1: Lead-acid type venting batteries have well-known safety risks, such as acid-spillage and venting of noxious gases. There are also safety risks with other battery types, such as thermal runaway. Care should be taken with the specification of battery, and the appropriate installation and control.

NOTE 2: Batteries may heat up in operation if placed under stress by high load demand. A battery temperature monitoring system is recommended. A battery system may run with high current, producing additional heat, which can cause issues.

2.3(3) Battery compartments must:

(a) if used to isolate the passenger compartment from hazardous liquid or gas, incorporate compartment seals made of non-porous material which are resistant to corrosion; and

(b) be designed so that transmission of flames between battery compartments cannot occur; and

(c) have, affixed to the outside of each compartment, a visible warning label stating the total battery pack voltage, type of battery and the potential dangers associated with the battery; and

(d) be resistant to degradation in the presence of corrosive materials.

NOTE: The warning notice positioned on the outside of each battery compartment, as required by *2.3(3)(c)* can be achieved by moving or copying a battery manufacturer's warning label from one of the batteries to the outside of the compartment.

2.3(4) Where venting-type batteries are used, the design of the batteries or battery compartment must:

(a) provide for venting directly to the atmosphere of all gases given off by normal battery operation, and there must be no electronics or components that could be a source of sparks situated above the batteries, or near battery vent outlets; and

(b) incorporate trays to catch fluids expelled from the batteries with either:

(i) an absorbent neutralising mat in the tray, sufficient to retain all fluid; or

(ii) sufficient volume in the tray to retain all fluid; or

(iii) a drip tube that directs fluid into a catch tank of sufficient volume to capture all fluid.

NOTE:	It is critically important to vent the battery compartment as noted in *2.3(4)(a)*. During recharging of venting type batteries, hydrogen can be given off in quantities sufficient to create an explosion. Hydrogen is lighter than air so will rise in a battery box, so the vent out should be at the highest point, and the air inlet low down.

2.3(5) The battery installation must provide ready access for power disconnection of:

(a) in the case of a high-voltage battery pack, both poles of the system; or

(b) in the case of a low-voltage battery pack, not less than one pole of the system.

NOTE 1:	'Ready access' as referred to in *2.3(5)* would mean that the system could be accessed and the batteries disconnected in less than a minute without need for opening the compartment itself. Access to the batteries for maintenance, such as electrolyte top-up and battery cleaning, should require the use of tools to prevent accidental interference or tampering.
NOTE 2:	Within the context of this standard, 'high-voltage', as referred to in *2.3(5)(a)*, is defined as exceeding 60V DC or 25V AC.

Battery compartment forced ventilation

2.3(6) An electrically-powered low volume vehicle fitted with batteries which have the potential to emit a hazardous gas into an enclosed compartment during normal operations, must be fitted with a forced ventilation system that:

(a) is constructed of materials that are corrosion-resistant to any gas present; and

(b) is designed in such a way that it will not ignite any gas present; and

(c) will operate automatically whenever a hazardous gas could be produced; and

(d) continues to operate for three minutes after any period of automatic operation; and

(e) operates by extracting gas from the enclosed compartment, and not by blowing in air which could leak out of the compartment; and

(f) is adequately protected from mechanical damage; and

(g) has an inlet low down and an outlet at the highest point that are located at opposite ends of the enclosed compartment; and

(h) has an inlet and an outlet positioned to prevent flow of any hazardous gases into the passenger compartment; and

(i) has an air flow rate that is at least 25 times in excess of any gas evolution rate of the batteries.

NOTE 1: Examples of the types of designs referred to in *2.3(6)(b)* include a sparkles or brushless type fan motor.

NOTE 2: The inlet opening referred to in *2.3(6)(g)* should not be placed in the vicinity of the passenger compartment ventilation system inlets or outlets. With the vehicle in motion the outlet should preferably be in an area where the local air pressure is likely to be lower than static atmosphere pressure.

NOTE 3: Consideration needs to be given to filtering the air brought into the battery compartment, and venting potentially explosive gases away from any ignition sources and components susceptible to corrosion.

NOTE 4: A system with a back-up fan should be considered in high-risk installations.

NOTE 5: Where any doubt exists about the adequacy of the ventilation, relevant documentation must be provided from the battery manufacturer confirming that the designed airflow is adequate for the gas evolution conditions specified in *2.3(6)*.

2.3(7) An electrically-powered low volume vehicle that uses forced ventilation for cooling of components during operation, must be fitted with a system that:

(a) will operate automatically whenever cooling is required, such as during rapid charging; and

(b) has an air flow rate that is sufficient to cool where necessary during charge and drive cycles; and

(c) continues to operate for three minutes after any period of automatic operation; and

(d) is adequately protected from mechanical damage; and

(e) has an inlet and an outlet positioned to prevent flow of any gases into the passenger compartment.

NOTE 1: The inlet opening referred to in *2.3(7)(e)* should not be placed in the vicinity of the passenger compartment ventilation system inlets and outlets. With the vehicle in motion, the outlet should preferably be in an area where the local air pressure is likely to be lower than static atmosphere pressure.

NOTE 2: Where any doubt exists about the adequacy of the ventilation, relevant documentation must be provided from the battery manufacturer confirming that the designed airflow is adequate for the heat evolution conditions specified in *2.3(7)*.

NOTE 3: Consideration needs to be given to filtering the air brought into the battery compartment.

NOTE 4: The condition referred to in *2.3(7)(a)* could also occur with a low-voltage system under high load, or rapid heavy discharge scenario such as drag racing.

Battery position

2.3(8) Batteries used to power an electrically-powered low volume vehicle must not be positioned in such a way that there is a high risk of damage during a crash.

NOTE 1: Wet type, or flooded, batteries may release large amounts of acidic fluid when damaged, causing an injury risk to emergency services and occupants.

NOTE 2: Batteries of any type should not be mounted far-forward in the engine bay where they are vulnerable in a frontal impact.

2.4 Vehicle operation

Instrumentation

2.4(1) The instrumentation of an electrically-powered low volume vehicle must provide to the driver, a clear visual indication of:

(a) when the traction motor circuit is live; and

(b) the state of charge of the batteries *(see note 1)*; and

(c) when the handbrake is on *(see note 2)*; and

(d) in the case of a vehicle fitted with power assisted brakes, such as from a vacuum feed, a loss of power assistance that may result in a loss or reduction of braking performance *(see notes 3 and 5)*; and

(e) in the case of a vehicle fitted with a forced ventilation system, the failure of the ventilation supply; and

(f) where the components are suitable, the occurrence of a ground fault (isolation failure), accompanied by an audible warning *(see note 5)*.

NOTE 1: The requirement specified in *2.4(1)(b)* is necessary to provide an indication of remaining range and can be a voltage reading or calculated from battery management system (BMS) data.

NOTE 2: The handbrake and brake vacuum warning lights specified in *2.4(1)(c)* and *(d)* are critical to show that the braking system is performing properly, as there is no back-up engine braking as would be available with an internal combustion engine.

NOTE 3:	The brake failure warning light specified in *2.4(1)(d)* must be able to be tested by turning the ignition switch to 'start' or 'test' position.
NOTE 4:	The ventilation supply warning light specified in *2.4(1)(e)* for a gas venting situation should be active when the charging system is in operation.
NOTE 5:	A ground fault detection system as specified in *2.4(1)(f)* is not a mandatory requirement because it may not be compatible with some motor and battery types. Brushed DC systems will always have some earth leakage due to conductive dust from the motor brushes, and flooded batteries may cause some earth leakage due to conductive mist vented during charging. The aim is to detect a ground between the battery voltage and the vehicle structure or body (if made of conductive material). To test (as part of the LVV certification process), a suitable resistor can be connected between several electrical positions within the battery group, and several places on the vehicle structure/body (including the structure near the battery), and then check that the leakage detector detects it.
NOTE 6:	Despite the requirement for an interlock device in *2.2(6)(a),* LVVTA recommends that a warning light also indicates that an external battery charging system is connected.

Accelerator

2.4(2) An electrically-powered low volume vehicle must have an accelerator pedal *(see note 2)*, and an associated control mechanism for the control of the electrical motor and circuitry, incorporating a fail-safe design *(see notes 1 and 3)*.

NOTE 1:	A single-sliding contact-type potentiometer alone is not fail-safe, as a fault can cause a high reading and effectively full throttle. A hall-effect sensor or wire-wound potentiometer is acceptable, but it must have at least one secondary safety feature, such as a throttle-shut micro-switch or brake-on micro-switch.
NOTE 2:	A motorcycle may use an alternative control instead of a pedal, as appropriate.
NOTE 3:	As specified in the *New Zealand Car Construction Manual*, a modified or custom-built accelerator system must be fitted with a minimum of two return springs that work independently of each other.

Transmission

2.4(3) The transmission of an electrically-powered low volume vehicle with an electric reversing switch fitted, must incorporate an operative inhibitor switch that will prevent the electric reverse switch from being inadvertently engaged during forward motion.

NOTE:	Slow-moving electric vehicles can be very quiet; - LVVTA therefore recommends that a reversing alarm which will be audible to nearby pedestrians is fitted. A wide-angle rear-view camera may also reduce the risk to safety.

Braking system

2.4(4) Where power assisted brakes, such as vacuum or air-boosted hydraulic brakes, are fitted to an electrically-powered low volume vehicle, the vehicle must incorporate, in order to ensure safe operation in the event of a power-assist supply failure during electric drive operation:

(a) an alternative power supply, in order to maintain safe braking performance for a minimum of two stops; and

(b) a brake failure warning light that notifies the driver of the situation, as required by *2.4(1)(d)*.

2.4(5) During a brake-performance test carried out as part of the low volume vehicle certification inspection process, any system that is supplementary to the type specified in *2.4(4)* that may aid the braking process, such as electric motor regenerative braking, must be disengaged for the duration of that test, unless disengagement of the system is not possible *(see note 1)*.

NOTE 1:	*2.4(2)* of *LVV Standard 35-00 (Braking Systems)* requires that a low volume vehicle is able to meet the specified brake performance requirements without the deliberate aid of engine compression. Therefore, any electrical equivalents must not be used to achieve the same effect.
NOTE 2:	When any electric engine conversion (and associated batteries etc) results in a significant increase in mass, particular attention should be paid to the condition and durability of all braking components, including the rotors, calipers, pads, drums, and shoes, along with wheel hubs and bearings.

2.5 Manufacturer's GVM and MAR

2.5(1) An electrically-powered low volume vehicle must not exceed the vehicle manufacturer's gross vehicle mass or either of the vehicle manufacturer's axle ratings, for that make and model of vehicle.

2.5(2) In the case of an electrically-powered low volume vehicle which, due to the addition of heavy components such as batteries, has an increased tare (unladen) weight, or a change in axle load distribution:

(a) the spring rates and shock absorber damping capability must be suitable for the increased unladen vehicle mass or axle load, and enable the vehicle to maintain similar handing characteristics and comfort levels to that of its unmodified condition; and

(b) the vehicle's wheel-stud number and size must be suitable for the increased unladen vehicle mass or axle load; and

(c) the vehicle's increased unladen vehicle mass or axle load must not cause the load-rating of the tyres to be exceeded; and

(d) the vehicle's steering characteristics must not be reduced below a safe tolerance of the original vehicle's, despite its increased unladen vehicle mass or axle load; and

(e) the vehicle's braking performance, both in one-off emergency braking and cyclic fade resistance brake-testing, must be sufficient for the increased unladen vehicle mass or axle load; and

(f) the amount of deflection throughout the vehicle's structure, both in bending and twisting, must not exceed, despite the increased unladen vehicle mass or axle load, that of the same make and model of vehicle in an unmodified form.

NOTE 1: The manufacturer's gross vehicle mass cannot exceed the sum of the manufacturer's axle ratings for the front and rear axles.

NOTE 2: When weighing a vehicle to determine that the manufacturer's GVM has not been exceeded, a simulated occupant weight of 80 Kg must be applied to each seating position, and any equipment must be in its maximum weight state, such as full water storage tanks.

2.6 Other requirements

Warning labels

2.6(1) LVVTA-approved warning labels, of a minimum size of 100 mm x 100 mm, incorporating the symbol of a triangle containing a lightning bolt using black text and imagery against a yellow background, must be:

(a) positioned, together with the words 'electric vehicle', in a prominent exterior location, so as to alert emergency service personnel who may need to attend to the vehicle, of the presence of an electric shock hazard; and

(b) positioned, together with the words 'high-voltage', prominently on the covers of all compartments which contain high-voltage, so as to alert anyone who may need to service or repair the vehicle, of the presence of an electric shock hazard.

NOTE 1: Within the context of this standard, 'high-voltage', as referred to in *2.6(1)*, is defined as exceeding 60V DC or 25V AC.

NOTE 2: It is intended that the labels make the presence of an electrical hazard obvious, however it is not intended that every component of the electrical system be individually-labelled.

NOTE 3: A prominent location, as required for the label specified in *2.6(1)(a)*, is considered to be a highly-visible area such as the front and rear bumpers, close to the vehicle registration label, or on the driver's door.

NOTE 4: An example of a compliant label design for a high-voltage symbol is shown in *diagram 1.1*. Alternative designs may be accepted on a case-by-case basis.

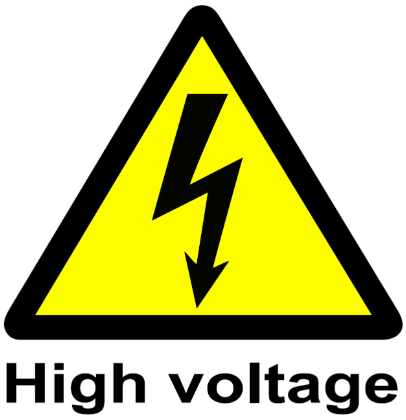

Diagram 1.1 Warning label sample

Compliance with other technical requirements

2.6(2) An electrically-powered low volume vehicle must also meet any applicable technical requirements specified in:

(a) *Low Volume Vehicle Standard 85-40 (Engine and Drive-train Conversions)*; and

(b) *Low Volume Vehicle Standard 195-00 (Suspension Systems)*; and

(c) *Low Volume Vehicle Standard 155-30 (Frontal Impact)*; and

(d) *Low Volume Vehicle Standard 155-40 (Interior Impact)*; and

(e) *Chapter 5 (Chassis Modification and Construction)* of the *New Zealand Car Construction Manual*; and

(f) *Chapter 7 (Steering Systems)* of the *New Zealand Car Construction Manual*; and

(g) *Chapter 18 (Attachment Systems)* of the *New Zealand Car Construction Manual.*

NOTE 1: All electrically-powered low volume vehicles, including those production vehicles with relatively straight-forward electric engine conversions, will potentially affect compliance with some parts of the LVV standards and *New Zealand Car Construction Manual* chapters listed in *2.6(2)(a)* to *(g)*, and therefore must be assessed against those standards and chapters in every case.

NOTE 2: Due to the high torque of electric motors, motor and transmission mounts may need to be stronger than original equipment types.

Extensively modified and scratch-built LVVs

2.6(3) All electrically-powered low volume vehicles which are either scratch-built, or are modified to such an extent that they are beyond the scope of the applicable requirements referred to in *2.6(2)(a)* to *(g)*, must comply with any relevant design and construction requirements specified in the applicable chapter of the *New Zealand Car Construction Manual*.

Section 3 Exclusions to this standard

No exclusions apply to this low volume vehicle standard.

Section 4 Vehicles that are not required to be certified to this standard

4.1 Vehicles not covered by this standard

4.1(1) A light vehicle is not required to be certified to this low volume vehicle standard, if the vehicle is modified for use for law enforcement or the provision of emergency services.

4.2 Vehicles that pre-date legal requirements

4.2(1) A light vehicle is not required to be certified to this low volume vehicle standard, if the vehicle:

(a) was converted to electric or hybrid power in New Zealand before 1 January 1992; or

(b) was scratch-built using electric or hybrid power in New Zealand before 1 January 1992.

(c) had modifications made to the electric or hybrid systems in New Zealand before 1 January 1992.

Section 5 Terms and definitions within this standard

Ampere (amp or A) means the unit of electric current; one ampere is the current passed by one volt through one ohm of resistance.

Anderson connector	is the brand-name of a high-current rated multi-pole connector, commonly used as a mechanical disconnect for both poles of a battery pack.
Battery	refers to a series of electro-chemical cells, joined together electrically via links or cables, either internally or externally, to form a battery. In some cases, the cells may be physically located as 'groups' in separate containers and these separate groups of cells may then be connected via external cables or links to provide the higher voltage battery pack to drive a motor vehicle.
BMS	means Battery Management System, which monitors and controls the batteries.
Charging	means the method of forcing electric current in the reverse direction into a storage battery, inducing a chemical change that stores the energy.
Circuit breaker	means an electrically-controlled re-settable switch that interrupts the electricity circuit if an overload occurs.
Contactor	means an electrically-controlled switch used for switching a power circuit, the higher current rating version of a relay.
Current shunt	means a low resistance device which provides a way of measuring large currents in a circuit by measurement of voltage drop across it.
Fail-safe	means to default to the safest mode in the event of a common failure such as a broken connection in the switch wiring. Fail-safe design always starts with an assumption as to the most likely kind of wiring or component failure, and then tries to configure things so that such a failure will cause the circuit to act in the safest way, this being determined by the physical characteristics of the system.
Fuel cell	means a device that generates electricity from a chemical reaction, such as the interaction of hydrogen and oxygen through a catalytic membrane.
Fuse, fusible link	means a mechanical device that interrupts the electricity circuit if an overload occurs.
Gross vehicle mass (GVM)	means the combination of the tare (the un-laden weight of the vehicle), plus the amount of load that the manufacturer certifies that the vehicle can carry.
Ground fault detector	means a device that detects a connection between the battery and the body of a vehicle. Such a connection will allow a current to flow through a person who simultaneously touches the body of the vehicle and part of the battery during maintenance. A second connection between the vehicle body and a different part of the battery will allow current to flow through the vehicle body, potentially causing a fire or damaging the battery.
High voltage	means any situation where voltage exceeds 25 volts AC or 60 volts DC, as designated by UN/ECE regulations.

Hybrid	means a vehicle powered by two or more power sources, for example electric and petrol.
Isolation switch	means a switch that cuts the power. The master isolation switch allows the driver to cut power to the motor. The maintenance isolation switch disconnects the high-voltage battery pack to enable access and maintenance.
Manufacturer's axle rating (MAR)	means the maximum load that the vehicle manufacturer certifies that the axle can carry.
Original Equipment (OE)	means as originally fitted by the vehicle manufacturer to that specific vehicle.
Over-current trip	means a device which automatically interrupts the electrical current in a circuit if the level of this current exceeds a defined limit value. Fuses and circuit breakers (but never the motor circuit breaker) count as over-current trips. Extra fast electronic circuit fuses and fast fuses are appropriate.
Regenerative braking	means a braking effort due to the electric traction motor acting as a generator and returning energy to the traction batteries.
Short circuit	means an abnormal low-resistance connection in an electrical circuit. This results in an excessive electric current and potentially causes circuit damage, overheating, fire or explosion.
Solar cell	means a device that converts sunlight to electricity.
Thermal runaway	means generation of heat in a battery to a dangerous level. If batteries are charged too fast, heat is generated which in turn creates Hydrogen (known as gassing). As the battery heats up, more hydrogen is created and the risk of explosion increases. The danger posed by high Hydrogen concentrations is one of the reasons that batteries must be installed in well-ventilated areas.
Torque	means rotating effort produced by applying a force to a lever arm about a pivot.
V	is an abbreviation for volt.
Volt	means the unit of electrical pressure, or electromotive force.

NOTE:	The terms and definitions found in section 5 are limited to those terms and definitions that are unique to this low volume vehicle standard, and are not necessarily contained within the terms and definitions section of the *Low Volume Vehicle Code*.