DESIGN REQUIREMENTS
FOR CONVERSION OF MOTOR VEHICLES
TO ELECTRIC DRIVE IN QLD

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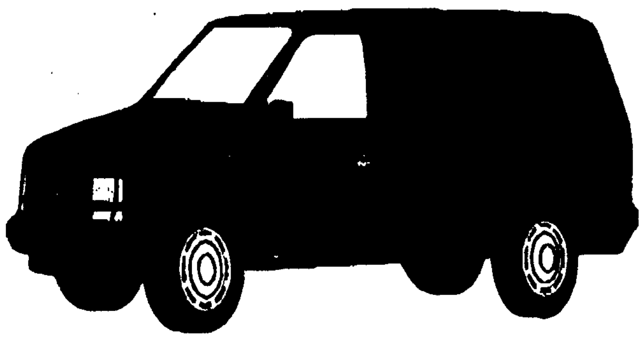

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1. COMPLIANCE WITH DESIGN RULES

Converted vehicles have to meet the same basic set of safety design requirements that applied to the original vehicle. Some of the requirements are set out as Australian Design Rules (ADR'S). Where any system governed by a design rule is altered, it is necessary to show that the original requirements of the rule are still met (this does not apply of course, to the rules on exhaust emissions if the internal combustion engine is removed, but it does apply to vehicle noise).

The vehicle remains compliant with all the Australian Design Rules that the vehicle was designed and built to meet in 1999.

2. BATTERY INSTALLATIONS

2.1 The batteries that power the vehicle must be fixed in position so that they will not break free in a crash and thus create any hazard to the driver or passengers or any other road users. The battery restraining system must adequately withstand crash deceleration of 20G (eg 20 times battery weight).

Total of battery and container weight	.............kg
Multiply by 20	.............kg
Divide by number of anchoring points	.............kg
Equal the sheer strength of each anchoring point	.............kg

(a) Battery Restraint – Engine compartment batteries;
There are 5 x 24kg lead acid batteries in the engine compartment, which are mounted on a galvanised iron frame. Each battery is held to the frame with 2 polypropylene straps rated at 280kg each, which is equivalent to a crash deceleration rating of 23G.

The galvanised iron frame is anchored to the chassis with 5 x M10 and 4 x M8 grade 8.8 high tensile bolts. The manufacturer of these bolts specifies a single shear rating (across the threads) of 26kN (M10) and 16kN (M8). This equates to 2,650kg and 1,630kg respectively at 1G. This gives a total anchoring capacity of 19,770kg. The 20G mass of the batteries and frame is ((5 x 24kg) + 15kg) x 20 = 2700kg. Therefore the 20G requirement is surpassed by a multiple of 7.

(b) Battery Restraint – Rear battery rack;
Similarly there are another 5 x 24kg lead acid batteries in a galvanised iron frame at the rear of the vehicle. A 12mm MS rod anchored in 4 positions holds down the batteries in this rack.

The frame is anchored to the two rear chassis cross members with 8 x M10 grade 8.8 high tensile bolts. Total shear strength = 21,200kg. 20G mass of batteries and frame = 2700kg. Therefore the 20G rating is also surpassed by a multiple of 7.

2.2 All batteries, including ancillary equipment batteries, must be effectively scaled off from the vehicle interior so that any liquid spillage or gas leakage into the vehicle cannot occur. (In general, the batteries must either be fully enclosed in a sealed vented compartment or must he individually scaled and externally vented).

Both battery racks are mounted externally to the body shell with no permanent openings between the batteries and the interior of the vehicle.

2.3 Any battery compartment must be constructed of a corrosion resistant material or be fully lined with a durable corrosion resistant material or coating that will not shrink or crack under extremes of vibration and temperature.

Both battery racks are made from 4mm galvanised steel. The rear rack has 1.5mm aluminium sheeting on all sides (to protect the batteries from debris).

2.4 Any battery compartment seals must be of a non-porous material resistant to corrosion.

Not applicable.

2.5 With the exception of any ducting used for ventilation, all battery compartment exterior openings or fittings (including the bore of any conduit) must be fully scaled so that the transmission of gas or flames is prevented (fully scaled and externally vented batteries need not comply with this).

Not applicable.

2.6 Any battery system which is sealed and externally vented or contains a common water replenishing device, must be designed so that propagation of flame between battery cases cannot occur.

Not applicable.

3. VENTING OF BATTERY COMPARTMENTS

3.1 The design of the batteries or battery compartment must provide for venting directly to the atmosphere of all gases given off by normal battery operation. This is of utmost importance with lead-acid batteries because, during recharging, hydrogen can be given off in quantities sufficient for an explosion.

3.2 Depending upon battery type and size of vent, a forced ventilation system might be required.

A forced ventilation system should:

(A) Be corrosion resistant and designed in such a way that it will not ignite vented gases (flameproof motors, etc).

(B) Operate automatically:
- When the batteries are on charge (including under regenerative braking, if used);
- When the batteries are discharging;
- For a sufficient time after the batteries are taken off charge so as to remove any residual gases contained within the battery cases;

(C) Operate by extracting gases and vapours from the compartment and not by blowing the air into the compartment (this is to make sure that if the battery compartment leaks, it will not result in a leakage of gases into the vehicle interior).

(D) Have an air flow rate well in excess of the gas evolution capacity of the batteries under charge and, if necessary, sufficiently large enough to cool the batteries while under charge and drive cycles.

(E) Be adequately protected from mechanical damage.

3.3 The battery compartment ventilation system needs an air inlet and outlet. The inlet should be located at the front bottom of the battery enclosure and the outlet located at the rear top of the enclosure (hot air and hydrogen rise). The inlet opening should be external to the vehicle. If not, it must have a pressure sensitive valve to prevent the reverse flow of gases and liquids into the vehicle interior. The inlet should not be placed in the vicinity of the ventilation system's outlet.

Both battery racks are not enclosed and consequently, by design, are directly vented to the atmosphere; therefore this section is not applicable.

4. POWER SYSTEMS

The electrical propulsion circuit must be isolated from other circuits in the vehicle. If safety equipment such as lights, brakes, windscreen wipers, etc use the same power source as the traction circuit. The design of any ancillary equipment supply should be such that satisfactory operation of all equipment, particularly brakes and headlights, is available throughout the discharge cycle of the traction batteries.

The electrical propulsion circuit is completely isolated from the original 12VDC vehicle electrical system. All propulsion cabling is, at minimum, double insulated from the body earth, and where exposed to chafing or abrasions, is also encased in rigid conduit. The exterior of the propulsion controller and motor, whilst both metallic, are electrically isolated internally. The propulsion circuit contactor, disconnect switch, fuse, relays and interconnects are all mounted inside ABS electrical enclosures with a minimum protection rating of IP64.

Apart from the petrol motor wiring, the original 12VDC system is intact, including the alternator, which is mechanically driven (and therefore electrically isolated) by the electric propulsion motor.

5. CONTROLS

There must be located within reach of the driver. A master isolating switch. If not of flameproof design, the switch shall not be placed in the battery compartment.

The master isolation switch is constructed so that the switching contacts are sealed from water ingress and therefore is spark suppressive. In addition to this the master isolation switch assembly is mounted an IP64 enclosure which is designed to stop foreign materials entering the enclosure from any direction.

The original ignition key operates the electrical propulsion circuit master switch. This is a normally open switch so should the 12VDC system fail, the master-operating contactor will open circuit. There is also a prominent manual disconnect stop for the electrical propulsion circuit mounted forward in the engine compartment. (Also the driver can remotely open the filler cap door which will open circuit the main contactor by design, see paragraph 8.5.)

6. ELECTRICAL INSTALLATION STANDARDS

6.1 All electrical control apparatus, the motor and major ventilation system components shall be effectively scaled or otherwise resistant to water and dust ingress.

The propulsion circuit contactor, disconnect switch, fuse, relays and interconnects are all mounted inside ABS electrical enclosures with a minimum protection rating of IP64. The propulsion motor and controller are splash protected by under-car moulded plastic guards.

6.2 All electrical installation work must be designed and executed in accordance with applicable codes and standards. All power unit wiring and connections must be, where possible, located outside the passenger compartment or load space in order to minimise the possibility of contact by operators or passengers. In cases where placement of electrical wiring in the passenger compartment or load space is unavoidable, the wiring should be contained with in a rigid protective housing.

There are no components or wiring of the electric propulsion system within the passenger compartment, apart from where used for instrumentation, in which case incorporates very low-current safety fuses.

6.3 It is important to ensure that the insulation of the traction circuit is suitable for its intended application. Most automotive cable is not designed for the higher voltages used in electric vehicles or for constant high current operations. The designer should make allowances for high peak currents in the stall and heavy acceleration modes.

All cable used for the traction circuit is double insulated (Nitrile/V90HT PVC) and meets or exceeds AS5000.1 - AS1995 standards and is capable of 560amp at 30% duty cycle. It is 70mm2 and is classified as “welding” cable.

6.4 All wiring must be effectively secured to the chassis at regular intervals of not more than 600mm. The wiring should be kept free from moving parts and be protected from chafing against sharp edges.

All wiring is secured to the body/chassis at no more than 600mm intervals and where exposed to chafing or abrasion is protected by at least one layer of rigid conduit.

6.5 All electrical control apparatus for the traction circuit should be designed on fail-safe principles (the failure of any individual component within the traction circuit should stop the motor).

Any failure of the variable control circuit (accelerator) results in controller shutdown. Any failure in the propulsion circuitry results in open circuit of the main contactor, which disconnects all power from the controller and motor.

6.6 Traction circuit limiting devices (eg a fuse or overload relay), should not be placed within a battery compartment but, nevertheless, must be connected as close as practicable to the batteries.

The traction circuit fuse in mounted inside the switching enclosure adjacent to the front battery rack.

6.7 If a wire or cartridge type fuse is used for current limiting and the vehicle has a direct current supply source, it is necessary that the fuse is rated by its manufacturer for use with direct current.

The main traction circuit fuse is rated at 500A DC.

7. OTHER CONSIDERATIONS

7.1 One problem, which must not be overlooked, is the possibility that some mechanical components of the converted vehicle might become overloaded because of the increase in weight caused by the addition of the traction batteries. This is particularly important with tyre and axle loadings of converted passenger cars and light commercials. Cheek that the strength of every such component is adequate for its new function. Remember: it's the weight of the laden vehicle that matters. Allow at least 68kg per passenger, plus 13.6kg for luggage. Total 81.6kg.

	FRONT	REAR
Laden weight at each axle	.... kg	.... kg
Manufactures maximum laden weight at each axle	.... kg	.... kg
Number of tyres at each axle	....	....
Tyre Size	....	....
Tyre ply rating	....	....
Tyre load rating	....	....
Total laden weight of vehicle		.... kg
Manufacturers maximum laden weight of vehicle		.... kg

Toyota Australia provided the following weight specifications for Toyota Echo 3 door hatchback;

	Rear	Front	Combined
Curb	420kg	530kg	= 950kg
GVM	700kg	675kg	= 1375kg

Calculated new curb weights are;

	Rear	Front	Combined
Curb	420 + 160(1) = 580kg	530 + 80(2) = 610kg	= 1190kg

Calculated new maximum laden weights (as a 2 seater);

	Rear	Front	Combined
Max	580 + 107(3) = 687kg	610 + 57(3) = 667kg	= 1354kg

(1). Calculated additional weight over the rear axles due to the battery pack, battery rack and battery support bracket assembly.
(2). Calculated additional weight over the front axles due to the battery pack and rack, minus the difference in weight between the petrol motor and electric motor.
(3). These weights are calculated as follows: All luggage (28kg) is over the rear wheels. Due to the rearward position of the front seats in this 2-door vehicle (with respect to a wheelbase of 2.4mtrs) the passenger weight is offset towards rear of vehicle by a ratio of 1.4:1.Therefore the total passenger weight of 136kg is divided into 79kg (rear) and 57kg (front).

7.2 If the vehicle is fitted with air or vacuum assisted brakes or power assisted steering, all alternative source of vacuum, air or power assistance must be fitted. The new source must be equal to or greater than the original source.

Vacuum original vehicle	.... IN.HG
Vacuum modified vehicle	.... IN.HG
Air original vehicle	.... KPA
Air modified vehicle	.... KPA
Power steering original vehicle	....
Power steering modified vehicle	....

The original vacuum assisted brakes are designed to operate at a vacuum of between -13"hg and -18"hg. This requirement has been met with the installation of a 12VDC electric vacuum pump (the model fitted is used extensively in electric vehicle conversions) and vacuum switch which is set to operate at –18"hg. As an added precaution the vacuum system has an added reservoir tank of 2.5ltrs capacity.

7.3 The fitting of the replacement electric motor must not require removal or weakening of sub-frames, chassis, cross or body members. The steering mechanism of the vehicle must not be altered in any way.

No alterations were made to the sub frames, chassis, cross or body members in the fitting of the electric motor. All three of the existing engine / transmission mounting points were maintained and not modified. The steering mechanism was not modified and is not of the power-assisted type.

7.4 Automotive type electric motor mountings must be used on suitably fabricated brackets to the satisfaction of the inspecting officer.

4mm mild steel was used for motor mounting bracket. This bracket attaches to the original engine mount using the original single M10 grade 8.8 bolt and incorporates the original safety cage mechanism should this bolt shear in a collision, as designed.

7.5 All access holes into the vehicle cabin for gear linkages, cables, etc must be suitably sealed to prevent the entry of road fumes.

All access holes to the vehicle cabin remained sealed as original, apart from the cabin heater water pipe entrances, which have been sealed appropriately.

7.6 It is the converter’s responsibility to ensure that the accuracy of the vehicle's speedometer is maintained.

No modification was made to the speedometer sender unit as it is mounted in the transmission drive shaft housing.

7.7 All work preformed must be in accordance with recognised engineering standards and to the satisfaction of the inspecting officer.

7.8 The removal of the heating source for windscreen demisting will necessitate the provision of an alternative source of heat or perhaps an alternative demisting arrangement. A performance equal to or better than that o C the original demisting system must be maintained.

The original heated-water demister element was replaced with a 12VDC 250W ceramic heating element.

8. POINTS TO REMEMBER

8.1 Any electrical potential greater than 32 volts, coupled with a large current capacity, should be regarded as dangerous.

The switching control enclosure is labelled “DANGER, HIGH VOLTAGES INSIDE”. There is no exposed high voltage conductive material that has access without the removal of protective covers and/or insulation.

8.2 Electric vehicles can be very quiet in their operation and, in some situations, this might result in increased risk for other road users, particularly pedestrians. Consequently electric vehicles must have effective horns and it is recommended that an audible reversing alarm be fitted.

No audible reversing alarm is fitted. However the controller produces a 1500Hz square wave at low speeds, which is transduced by the electric motor into a very audible “squeal” in either forward or reverse.

8.3 To ensure satisfactory service over the range of climatic conditions, it is recommended that electric vehicles be designed for prolonged operation in temperatures ranging from -10 C to +50 C.

All components are designed and manufactured to operate within the temperature ranges suggested of –10C to +50C.

8.4 Consider using current sensitive overload relays instead of simple wire or cartridge type fuses (current sensitive so that the current to the motor is reduced to a safe level when overload occurs). Solid state apparatus is acceptable. This will ensure that a total loss of control of the traction motor will not occur and if an emergency does arise, the driver will have the master-isolating switch at his disposal.

Only simple metal fuse used.

8.5 It is recommended that the charging socket be fitted with an interlock circuit, which immobilises the vehicle when the charging cable is connected.

The access door for the charging socket (original “fuel flap”) is fitted with a door switch and relay which acts as a safety interlock to disable (open circuit) the main contactor while the door is ajar.

8.6 Vehicles not fitted with a conventional gearbox and using a voltage reverse switch to select reverse gear should be designed so they cannot be accidentally placed in reverse, A switch with a lockout function is acceptable as is a separate "reverse" enabling switch.

The vehicle retains the original transmission and does not have an electric reversing circuit

9. SPECIAL NOTES

9.1 It is advisable to check with the appropriate electrical authorities concerning the recharging of electric vehicles in domestic or commercial environments.

Considered unnecessary as the vehicle uses a battery charger designed for a standard 240V 10A GPO.

9.2 Where applicable, the wiring should conform to AS/NZS 3000:2000 (or more recent editions),"Wiring Rules", in particular section 7 9,"Hazardous Locations".

To the best of my knowledge the vehicle wiring meets or exceeds the AS 3000:2000 wiring standards.

9.3 Further information can be obtained from Compliance Standards Transport House PO Box 673 Fortitude Valley 4006 (07) 3253 4851.