PROTECTION FOR EV COMPONENTS.

By Edward Booth

Introduction.

These guidelines have been drawn up to help the home-builder of EVs to safeguard their investment from some of the hazards.

They are not safety guidelines. This topic has been covered elsewhere, but there are some overlaps.

Electric vehicles use electricity, which is stored in batteries and conducted to various parts of the vehicle. They contain some very expensive and often delicate components, which are prone to damage from vibration, water, short circuits, electric "spikes", etc.

Components can be damaged by impact, abrasion, over-heating and over-revving.

Batteries can be damaged by improper charging.

It is possible to install safeguards against most of these hazards, and greatly improve the life of the components, reduce frustration and save money.

One of the most common reasons for not installing protective devices is ignorance, both of the need and how to do it. My advice is to **ask** someone who knows**. This is where membership of AEVA comes into its own.**

Water.

Water is the enemy of electricity. It must be kept out of all components, or failure can follow.

Water can gain entry from above, through ill-fitting covers during rain; from beside, through being thrown up by the wheels, or through the front grille; or from below, from deep puddles or suction off the road.

It follows that it is not enough to cover everything with a bonnet, but guards must be installed to protect from everywhere.

Most EV motors are made to withstand reasonable humidity, and, likewise, the controllers are usually well sealed in resin, but they cannot withstand being splashed.

It is not particularly difficult to provide splashguards to protect the underside of the engine bay. They must wrap up beside the major components to protect them from wheel spray. This requires that the axles pass through, but not water. Remember that the axles move up and down with the suspension!

The main protection for the motor is required around the brush housing. However, it is important not to prevent airflow for cooling.

Fortunately, the motor is usually a little forward of the axles, so it is not too difficult to achieve all of the above.

The controller, throttle pot and contactors are easily shielded once you know that you have to do it.

The batteries will tolerate a little moisture, but a build-up of mud near the terminals can cause some current leakage.

Vibration.

Vibration is not good for delicate electronic components. They should be mounted on rubber or similar damping material.

Vibration can cause chafing of cables and loosening of connections. Make sure that they are firmly located. Zip ties are good for this, and conduits are also helpful.

Spikes.

Sudden breaks and connections in current flow can cause voltage spikes and surges, which can seriously damage delicate electronics. The most significant of these is caused by switching of the contactor (the solenoid that livens the traction circuit when the ignition is switched on).

To get around this problem, a diode is used across the contactor (12Volt) coil terminals. The white band of the diode goes towards the positive terminal. This contains the ‘Back EMF’ from the coil and protects other devices in the 12V system from spikes.

A ‘Precharge Resistor’ is required across the contactor high tension terminals to allow the large capacitors in the motor controller to charge in a controlled manner. Without the ‘Precharge Resistor’ there would be excessive arcing and possible motor controller destruction due to extremely high inrush currents. The value of this resistor is important and different for each type of controller. The information that comes with the motor controller indicates the correct value.

In some cases, I have seen a capacitor used in lieu of the resistor, but there is a residual charge left across the poles after the circuit is switched off, and this can give you a nasty surprise. It is best to use the suggested resistor.

It is necessary for the manual switch (“the red knob”) to be switched on before the contactor, and also switched off after the contactor. This should minimise damaging spikes and high inrush currents. The turn on sequence mentioned here should be automated to allow a novice to be able to drive the car without having to remember the procedure.

Under-body Damage.

It is common for some of the batteries to be in the back of the vehicle, and this means that high tension cables will have to run the length of the chassis.

The cables are preferably mounted in the 'transmission tunnel', but they might have to be fixed under the floor or rocker panels. This makes them vulnerable to hitting speed humps and the like, which can rip them open and cause a short circuit or dangerous exposure.

To protect under-body cables, they should be in tough plastic or steel conduits. They should be coded or labelled so that they can be traced easily.

Anchorages.

A number of components will require anchorage.

Batteries must be anchored to comply with prescribed criteria (Bulletin 74 in SA). This will require hold-down brackets which must attach to the body or subframe to resist displacement in a collision.

The most common method of anchoring batteries is by 'post bolts' through the body and frame below.

These bolts must have washers or plates to reinforce them from below, but these plates must be radiused to prevent the corners from ripping through the sheetmetal, and they must be profiled to match the shape of the surface against which they are bearing. Failure to do this could result in the anchor failing, and you might also fail your registration inspection.

Avoiding SuddenUnexpected Events (SUEs).

The term SUE is a euphemism for an accidental short circuit. They can be very violent and dangerous.

SUEs are usually caused by inadvertently touching something with a 'live' tool, such as when tightening a battery connection and accidentally touching another with the other end of the tool.

Apart from being a safety issue, this can do considerable damage to terminals, tools and connected components.

Every effort should be made to keep terminals well apart, and, if possible install protective insulation.

Another cause can be dropping of a tool into a battery box or the like.

Battery Management Systems.

When a string of batteries is charged, they do not all charge at the same rate; some batteries reach full charge while others are well under.

The charger keeps pushing current into the batteries until the total voltage is equal to the float voltage of the charger. At this point, some batteries might be way over-charged while others are still under. Both batteries will suffer a reduction of life.

Regulators can be mounted across the individual batteries to bypass a battery when it is fully charged, and divert the charge to the less charged batteries. This goes on progressively, until the last battery is charged, the charger then goes into float mode.

Battery management systems are essential with Li/iron batteries, and highly desirable with Pb/acid. Claims of 100% extra battery life extension have been made, but even half of this will pay for the regulators several times over.

Over-revving.

Electric motors should not be revved unladen. Damage to the commutator is a common outcome.

When testing unloaded electric motors, no more than 12 Volts should be used.

It is a good idea to install a rev limiter to shut down the current if the motor exceeds a given speed.

The experienced EVer will never allow his motor to over-rev, but a newcomer could.

Overheating.

Electric motors should not be overheated.

Long, hard runs can cause a build-up of heat in spite of attempts to disperse it.

Many motors come with a thermal switch, which connects at about 150 degrees C. This should be connected to a warning buzzer or a cutout. **Do not ignore it!**

If the motor has no such device, you should install a small thermometer probe on the brush-housing and connect it to a gauge or buzzer in the cabin. Such devices have a bit of a lag, so it is well to set them to about 120 Deg C.

Small thermometers are available quite cheaply from electronics stores.

Motor controllers are usually designed to begin shutting down as temperature is increased above the normal range. Additional cooling via heatsinks and fans is sometimes necessary.

Dust.

Opinion is divided on this. There is no doubt that dust wears moving components, but there is a division about the damage caused by the small amount of dust to be found on most sealed roads, Some people advocate an air-cleaner to protect the motor ventilation, while others do not.

I have not seen any evidence to convince me that air filtration is necessary on normal roads.

Gauges.

It is useful to have gauges to show battery voltages, motor voltage and current draw. These are not *essential,* but are desirable.

After a while the EVer will know instinctively what is going on with current and motor volts, but these gauges will help you to avoid abuses, and monitor performance.

The voltmeters on the traction and auxiliary batteries are simply fuel gauges, and help to keep track of battery levels. They can save embarrassment.

A simple buzzer connected to the interior light switch is useful as a warning that you have not switched off the ignition. This is easy to do when there is no sound to warn you, and can save the batteries from accidental discharge.

Spare Parts.

Ensure that you have spare fuses, relays and other parts available in case of failure. Many of the parts required for electric car conversions are not available in Australia, so it is wise to purchase these and have them on hand – just in case.

Summary.

The above lists some of the most common points by which you can protect your investment and save yourself an embarrassing wait on the roadside. In every case, the cost of installing the preventative device will save its cost many times over.

It is often only lack of knowledge that causes builders to omit these devices, and they should seek advice.

Advice and diagrams should be available by just asking around at AEVA meetings.