ECONOMICAL ELECTRIC VEHICLE OPERATION

Adapted from the owner's manual for Jet Industries Vehicles

Descriptions of driving techniques described herein specifically apply to Jet Industries, Inc. electric vehicles, but the principles can be applied to any series wound electric motor powered vehicle.

INTRODUCTION

Although an electric vehicle (EV) and an internal combustion vehicle (ICE) may appear to be identical, drivers must adjust their driving habits to fit the different mode of driving required by the EV. Until a driver has received proper instructions to modify his driving technique to conform to this mode, he cannot operate the vehicle safely or properly, nor obtain the vehicle's maximum range or efficiency.

The first reality of EV operation is a range limitation that requires planning and forethought. Energy conservation is not a new term to any of us, but when the percent of charge gauge reads 20% and you are 20 miles from home, it takes on a whole new meaning.

Economical operation of an ICE requires moderate acceleration, shifting up through the gears at the lowest possible RPM until the desired cruising speed is attained. The low fuel flow, low RPM and low throttle driving technique essential for economical operation of an ICE will reduce the EV's range by 50% to 70%! The drastic difference in range as a result of driving technique is related to the different methods used to convert the battery's energy into rotary mechanical motion.

An electric motor's highest torque is just before it stalls, at very low RPM and highest current draw. As RPM increases, torque and current decrease, as does the amount of heat developed in the motor cables. Simply stated: An electric motor running at its fastest safe RPM will draw the lowest current. This is equivalent to low fuel flow in an ICE. The energy in an EV is stored in the battery pack, which can be related to an ICE gas tank. The slower we remove this energy, the longer the range. The fastest safe RPM of an electric motor is equivalent to the red line of an ICE for the same reason.

Now is the time to evaluate driving requirements. Things to consider are:

1) Highway or city stop-and-go driving

2) Desired cruising speed

3) Is a normal or aggressive acceleration rate required or desired

We will examine several driving situations and explain why more conscientious attention to driving requirements is necessary in an EV. Eventually the EV's operation will become as routine to you as operating an ICE is now.

DRIVING SITUATIONS

1) Speeds up to 25 mph: Stop-and-go city driving with no aggressive acceleration

Turn the key on, disengage the clutch, shift into 1st gear, engage the clutch, release the parking brake, and gently press the accelerator pedal while watching the ammeter gauge. Limit the initial current to about 250 amps by not pressing the pedal any further when 250 amps is reached. As the motor's RPM increases, the current will begin to decrease. Press the pedal just enough to keep the current at 250 amps. It will be a process of press and wait, press and wait, until the pedal is depressed as far as it can go. Continue to hold the pedal down. The speed will increase to 25 mph and the current will decrease to 100 amps.

An EV can be driven with the accelerator pedal on the floor for long periods of time on level ground at its maximum speed without damaging the motor.

When approaching a stop, release the accelerator pedal about a block from the stop and watch the current decrease to zero, indicating electrical energy is not being used. Let the vehicle coast. Note how little speed is lost before applying the brakes. Do not disengage the clutch. Just apply the brakes until the vehicle stops. To start again, release the brake pedal and gently press the accelerator pedal, not exceeding 250 amps. Wasn't that easy? Like driving an automatic, isn't it?

Although some drivers have expressed a feeling of acceleration when they released the accelerator pedal, this is because they expected to feel an engine's braking action to slow the vehicle. Engine braking is nonexistent in an EV. An electric motor's armature allows it to coast a long way using the kinetic energy stored in the vehicle.

NOTE: The speeds displayed on the instrument panel and listed in the owner's manual should be considered *minimum shift speeds* unless an aggressive acceleration is necessary.

2) Speeds over 25 mph:

If a cruise speed higher than 25mph is desired, disengage the clutch, shift into 2nd gear (see note above), slowly engage the clutch, and press the accelerator pedal, limiting the current to 250 amps as before, until your desired speed is reached.

Again to stop: Release the accelerator pedal early. Do not disengage the clutch. Coast. Brake. Just before the vehicle stops completely, shift from 2nd to 1st gear without using the clutch. Do not try to shift if the vehicle is moving faster than a very slow crawl - almost stopped. If stopped, and the gears are hard to shift, use the clutch as when you originally started. If you disengage the clutch when you are stopping, the motor will be running (coasting). When you engage the clutch in preparation to start again, the vehicle will jerk perceptibly as the coasting motor is suddenly stopped.

It is customary to downshift an ICE for engine braking, to slow when going downhill, or as an aid in stopping. DO NOT DOWNSHIFT AN EV FOR THESE PURPOSES! The low inertia of the armature in EV motors will not aid in braking action. Instead, the motor will be damaged by overspeeding.

The motor also can be damaged by overspeeding if you allow the vehicle to exceed the maximum speed for the gear in which you are driving, even if you release the accelerator (for example, going down a hill or a long decline). The maximum speed is the fastest ground speed in each gear. This **MUST NOT** be exceeded to protect the motor. Brake or shift to the next higher gear.

3) Normal or more aggressive acceleration:

A more aggressive acceleration can be achieved by limiting the current to 300 amps until the accelerator pedal is on the floor, shifting when the current decreases to 200 amps. Maximum acceleration is achieved by slowly pressing the accelerator pedal to the floor and shifting when the current decreases to 300 amps. Be cautioned that operating at 300 to 350 amps for more than a short time will overheat and damage the "ALL SAFE" cables and battery post, and will materially shorten the EV's range. (Shifting points may vary due to slope of terrain or acceleration requirements in traffic.)

DRIVING TIPS AND CAUTIONS

1) An EV drives so much like an automatic ICE that some operators will start off in 2nd gear and not shift at all. This is also a waste of energy. Try this: Start in 1st gear and note how much current it takes to start the vehicle moving - about 80 to 100 amps. Now try the same thing in 2nd gear and see how much energy is wasted.

2) Operating in too high a gear, and thus requiring a large current draw to maintain speed, will cause an increase of about 100 degrees F in the controller by overworking the freewheeling diode.

3) Economy is better achieved toward the top of the speed range in each gear, while acceleration and torque are maximized at the lower end of the speed range. The desired acceleration may require using all the gears through 3rd or even 4th. Once you have accelerated, downshift to 2nd gear to cruise at 45 mph and 100 amps. However, do not downshift if your speed is greater than the maximum speed for the gear into which you are shifting.

Picking the cruising speed that matches your EV's gearing can optimize its performance. Try this experiment: On ground level, operate at the top speed of 1st gear and note speed and current. Now shift to 2nd gear and drive 5 mph faster. Note the current draw. About twice the current is required. Is the speed increase worth it?

4) You are cruising on level ground with the accelerator pedal held to the floor, drawing 100 amps, and you start up a hill. The speed will decrease and the current will increase. If the loss of speed is not desired, upshift to the next higher gear and press the accelerator to maintain speed. This will require more current than letting the speed decrease. When you are again on level ground, downshift for economy. This same technique will allow you to accelerate when passing.

CONCLUSION

Properly trained and willing operators are essential to achieve optimum operation of EVs. Operators must be willing to change their customary driving habits to conform
with the operational requirements of EVs. They have to realize that, unlike when driving an ICE, they must learn to:

1) Accelerate less aggressively.

2) Drive more smoothly and consistently.

3) Anticipate normal stops earlier, thereby taking advantage of the EV’s coasting ability.

Finally, due to basic differences between EV motors and ICE engines, operators must also realize that driving with the accelerator pedal on the floor, with the vehicle in proper gear, is not abusive or detrimental to the motor, but desirable and necessary for its most efficient and economical operation.