7¼ Inch Gauge Society Limited

Driving a Battery Electric locomotive

Version 1.1
March 2025

Introduction

This manual is intended to introduce Trainees into driving Battery Electric Locomotives as part of the 7¼" Society Proficiency Scheme Gold Award, but may be used as guidance for any club to help train their drivers.

To use this manual for the Gold Award you need to have achieved at least the Silver Award first.

Thanks are due to Ivan Hewlett for drafting this guide, and to the many other people, who helped develop these notes further.

Before we ever think of driving; there are many things that need to be understood and things to be put in place. Importantly, you need to be sure you have the appropriate insurance paperwork is in place when driving with passengers. This will be covered in detail in another module.

For this manual we define a Battery Electric Locomotive as a motorised vehicle using Batteries as the power source. The vehicle may have a riding truck coupled to it for the driver to sit on which may contain some of the equipment mentioned in this manual or may be a self-contained unit like a Tram.

Proficiency Scheme Co-Ordinator.
March 2025

This manual covers:-

- Preparation; including pre-running checks
- Running
- Disposal

Battery Electric locomotives are often a cost effective and relatively simple introduction to owning, running, or even building, a miniature railway engine.

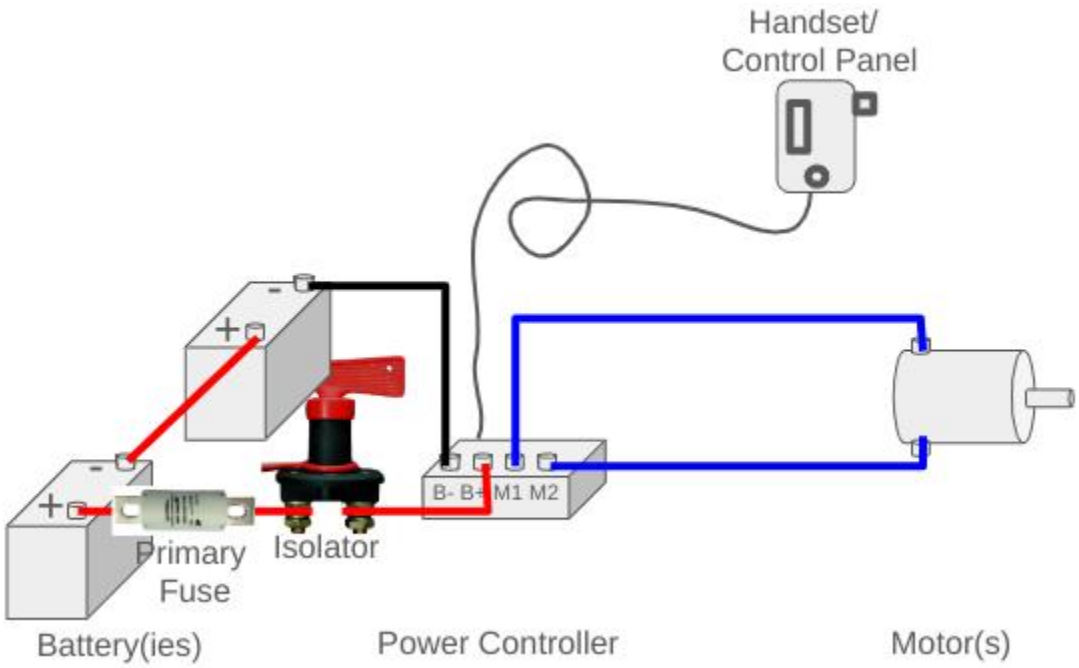
This manual is intended to support and enhance your journey into locomotive operation on a miniature railway, providing some information on design elements, guidance on safe use of the engine and things to consider when your running session ends.

Elements of a Battery Electric locomotive.

A Battery Electric locomotive consists of the following key elements:

- Battery, or batteries; this is the ‘energy source’.
- Power Controller; this manages the power from the energy source to motor, or motors.
    - Handset or Control Panel; this is a sub element of the Power controller and provides the driver interface to the locomotive.
- Motor, or motors; these convert electrical energy to mechanical energy to drive the wheels.
- Chassis, Bogies, Bodywork, Brakes (Due to varieties available, these are not covered)

Simplified block diagram of a Battery Electric locomotive (excluding final transmission)



Safety considerations

This module should be read in conjunction with the Health and Safety guidance document that can be found on the 7¼" Gauge Society website.

Miniature railways are a fun hobby and building or owning a Battery Electric locomotive should be fun in its own right. However, in order to ensure it remains enjoyable there are some important considerations to keep yourself and others safe around them.

With this in mind let's consider some sensible precautions around the various elements of a Battery Electric locomotive.

Energy source, Battery, or Batteries. The power to move your locomotive and any train attached to it is provided from the battery. This stores a large amount of energy (how much depends on its 'capacity'). The energy is stored in some form of chemical process, dependent on the battery type, and is released as electrical power through its external terminals. The rate at which the energy is released as power depends on the load connected to the terminals, this is normally managed to safe levels by the Power Controller under the driver's control.
There is no built in, or automatic, power limit within the battery and if the terminals become accidentally directly connected (a short circuit), then the energy may discharge at an excessive rate. This can lead to overheating of the short circuit, overheating of the battery, or in extreme cases explosion of the battery.

Consider using either plastic based tools to work on your locomotive, or limit any metallic tools to short length which can reduce the risk of terminal shorting.

Note, currently the vast majority of Battery Electric locomotives, particularly in 7¼" gauge, use 'wet cell', lead acid batteries, typically car batteries, leisure batteries or specialist 'traction' types. These all use lead based plates suspended in an acid bath. This type of battery has certain risks as described, but does benefit from a reduced risk of fire or thermal runaway when compared to newer types. They are also more forgiving regarding charging. Newer types include Lithium based batteries, such as used in modern Electric Vehicles (EV's), or even Supercapacitors, though these are less common.

Primary Fuse, or circuit breaker. There is limited risk from the item itself, although a large fuse can rupture noisily, or spatter small quantities of molten link. However, the greater risk is from not installing, or bypassing, such a device as it is a primary protection against excess current flow, perhaps due to loose connections or component failure.

Isolator. An isolator of some description is usually present on all Battery Electric locomotives and should be easily reachable.

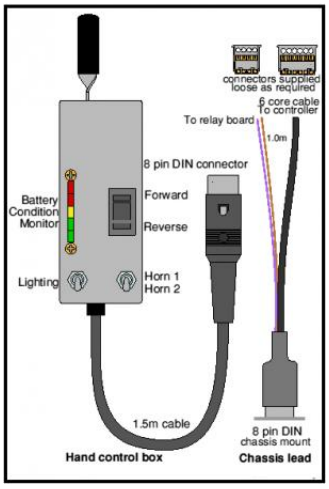
Power Controller. The power controller controls the flow of power from the battery(ies) to the motor(s), there are a huge number of different types and they may be commercial types, from recognised suppliers, or home made designs. The type of power controller fitted does not usually affect how the Battery Electric locomotive performs in use, although certain specific features may vary between locomotives and can affect Preparation, Running and Disposal. All power controllers essentially have two main elements:

- High current power control for motor(s)
- User interface, eg: handset or control panel

From a driver's point of view there are no direct safety risks from the Power Controller, although, as covered in Preparation, due to the high currents that can flow through the controller and connections care should be exercised around the connections themselves.

Note: Some controllers have a 'knob' which the driver turns to control speed. If this is a free-running type with no 'geared' positions, then there is a danger that unintentional operation may occur thereby causing an accident due to the 'free turning' of the knob. In these cases, the driver of the locomotive needs to pay additional care.

All power controllers should have a 'dead man's handle' of some sort. In the case of the 'dial' speed controller, this tends to have a cable that is attached to the bottom of the controller with a pin that, when removed, breaks the connection to the electrical circuit and thereby denies the engine of power.



The controller to the left shows a 'lever' method of stopping the locomotive in the event of a catastrophic event. This is a more intuitive controller where the driver has to depress the lever in order to provide the engine with power. In this method, there is no need to pull anything to stop the engine, it is merely the lack of electrical power as determined by the lever that either controls the speed, including breaking the electrical circuit in the event of a catastrophic event.

Motor(s). The motor, or motors, convert electrical energy into mechanical energy and drive the locomotive wheels, through some form of transmission system. The transmission system is not covered in specific detail here, but typically it will use either chains and sprockets, or gears, however lots of other types are possible.
Again risks to a driver are relatively low, the most likely perhaps being the possibility of burns from parts of a motor that might get hot in use, particularly under fault conditions. However, a general safety consideration with any vehicle is entanglement, in other words getting fingers, hair or other body parts caught in machinery. Avoid putting fingers or hands near transmission elements and also be aware of allowing long hair, or loose clothing, to become entangled.

Brakes. This module focusses on driving a Battery Electric locomotive and hence covers considerations related to the locomotive braking systems. Where the locomotive is being used with a separate driving truck, either on a private or club track, it is likely that other braking systems may be available from this vehicle. Examples of braking systems that may be fitted to a driving truck may include, separate mechanical brake or continuous air or vacuum systems. Whatever systems are available always ensure that you know how they work and understand their use.

Preparation.

As driver of a Battery Electric locomotive, you are responsible for the safe operation of your engine and this includes ensuring that it is fully prepared for use, whether you are setting it up for the first run of the day, or taking over from a previous driver during a running session.

Preparing the locomotive for a running session. There may be features of the specific locomotive that you are intending to drive and these may be explained in a manual, or more often will be explained by the owner or builder of the locomotive, in either case ensure that you are familiar with these features.
Alternatively, if you are in a situation where you are driving a Battery Electric locomotive for the first time and there is no third party advice or support available then take time to understand the features of the locomotive, as far as possible, before proceeding.

The following steps are advisable to follow when preparing any locomotive and should become intuitive over time.

1. **Visual inspection**.
    a. Look over the locomotive to ensure that it appears in good condition;
        i. Is the bodywork in good condition and is it clean?
        ii. Is there a built-in control panel, if so, are all controls present and in good condition?
        iii. Is there a handset, if so, is the cable in good condition and does it connect to the locomotive correctly?
        iv. Are all controls on the handset present and in good condition?
        v. Is the ‘dead man’s handle’ cable in place – if a dial system controller or similar
        vi. Does the locomotive have a mechanical braking system, if so, is this in good working order, do you understand how to operate the brake?
        vii. Does the locomotive roll freely in both directions? If not check whether this is ‘normal’ for this locomotive with the owner or builder*.
        viii. Are there any unusual noises when moving the locomotive? If so, check whether this is ‘normal’ for this locomotive with the owner or builder*
        ix. Are the batteries fitted to the locomotive, or do they need to be installed before use?
        x. Can the batteries be securely fitted into the locomotive?
        xi. Are the batteries correctly installed and connected, or are you able to do so?
        xii. Whether the batteries need to be installed, or are already in place, ensure that the isolator is in the OFF position at this stage.

xiii. Is there a primary fuse or circuit breaker installed? If so, ensure that you know where it is located.
xiv. Do all electrical connections within the locomotive look in good condition?
xv. Are there lubrication points on the transmission? If so, do you know where they all are? Do you know what type and quantity of lubricant to use?

2. **Preparation for use**.
    a. Preparing the locomotive at the start of a running session.
        i. Clean the locomotive, use separate cloths for the bodywork and the running gear.
        ii. Chain and gear drives should be reasonably clean, not covered in dust, dirt or leaf litter for example.
        iii. If the locomotive has coupling rods, check these for excessive wear or play.
        iv. Clean around lubrication points (where fitted) and lubricate for first operation.
        v. Ensure the mechanical brakes (if fitted) are working correctly.
        vi. Apply the mechanical brakes (if fitted).
        vii. Ensure that the handset is properly installed with all controls in the 'off' position.
        viii. If a control panel is fitted ensure this is turned off, or that all controls are in the 'off' position.
        ix. Before installing the batteries, or with the isolator in the off position, gently feel all accessible wiring connections, do they all feel secure?
        x. Install the batteries or turn the isolator on.
        xi. If the power controller has a separate 'ignition switch' turn this on.
        xii. Are all expected indicators displaying correctly;
            1. Is the battery indicator display (if fitted) showing correctly? Often a flashing display indicates a fault condition.
            2. Are voltmeters, if fitted, reading as expected?
                a. Typically a 12 volt battery should read between 12.2 volts and 14 volts (if new and freshly charged).
                b. Typically a 24 volt system should read between 24.4 volts and 28 volts (if new and freshly charged).
            3. Are there any warning 'beeps' present, this usually indicates a fault condition.
        xiii. If any fault conditions occur on initial switch on consult the owner or builder for advice*.
        xiv. If all indications are correct on initial switch on, then proceed.
        xv. Check that horns and ancillary functions, lights etc. are working correctly. (non-working lights, for example, may not prevent use, but a non-

functional horn might mean that the locomotive will not be allowed to run at club tracks due to their rules).

xvi. Check that any ‘dead mans’ device (if fitted) is working. Where a handset is used for control, a ‘dead man’s device, to turn the controller off automatically when activated, is highly recommended.

xvii. Ensure that the track where the locomotive is located is clear and it is safe to test the locomotive.

xviii. Operate the ‘dead-mans’ device to activate the controller.

xix. Select the required direction of travel, forward or reverse, release any mechanical brakes (if fitted) and gently increase power using the rotary speed control, trigger lever, or similar and ensure the locomotive responds correctly. Bring the locomotive to a stop.

xx. Select the opposite direction of travel and ensure that the locomotive responds correctly.

xxi. Once all above checks and tests have been performed proceed to Running.

xxii. Ensure that you are fully aware of all rules and practices related to driving on the railway before proceeding

b. Taking over driving of the locomotive during a running session.

i. If you are taking over driving of a locomotive that is already in service then there are still some checks to be made.

ii. Ensure that the locomotive is in a safe condition before taking over driving

1. Are the brakes applied (if fitted)?
2. Are the controls in a safe condition?
3. Is the dead-mans control active?

iii. Ask the outgoing driver if there are any issues or concerns related to the locomotive?

iv. Ensure that all conditions are as expected, including;

1. Voltmeter readings.
2. Battery indicator readings and status.
3. General condition.
4. Is lubrication required?

v. Ensure that you are fully aware of all rules and practices related to driving on the railway before proceeding.

Notes.

*In circumstances where there is no-one available to advise on such conditions then proceed with caution and investigate more deeply. Ideally seek advice from experienced Battery Electric owners or your local miniature railway club.

Running.

Ensure that you have authority to run your locomotive on whichever track you intend to use. This might sound obvious, but it can have different meanings dependent on where you will be driving the locomotive. For example, if you are driving on a private track in a garden then you may be the only person running on the track, but if you are intending to drive on a club track then it is essential that the 'Person in Charge' has authorised you to run on the track and that you can enter and run at the specific time.

Regardless of where you are driving your locomotive, in your own garden, on a private line or at a club track, as the driver you are responsible for the safe operation of your locomotive, you should remain alert and aware at all times.
Things to be aware of include, but are not limited to:

- Speed. Is your speed safe, in line with any restrictions and suitable for the conditions?
- Line ahead. Is the line ahead clear of obstructions and other trains?
- If other trains are running on the line, do you know where they are?
- Are there people, perhaps children and maybe dogs wandering around?
- Are you pulling a train?
- Are you carrying passengers on the train?
- Are you carrying members of the public, perhaps fare paying, on the train?
- Are you old enough and qualified to drive the train you are planning to haul?

Specific details of practices for driving at different railways will vary and are outside the scope of this module. This module assumes that all necessary pre-use checks ahead of starting the train have been performed and the train is ready for you to haul, as driver of your Battery Electric locomotive.

1. **Starting the train**.
    a. Consider the weight of your train, are you running light loco, lightly loaded train, or fully loaded passenger service?
        i. Release any mechanical brake (if fitted).
        ii. Sound your horn (if permitted).
        iii. In the case of a cable dead man's device, ensure it is in place to enable the activation of power to the loco. In the case of a lever operated dead man's device, this is incorporated in the speed lever and therefore, depressing the lever will provide the electrical circuit supplying the motors to engage, and releasing it completely will break that circuit, thereby starving the motors of power.
        iv. Gently apply power using the controller, the amount of power required will vary dependent on weight of the train.
        v. Once the train has started to move, use the controller to accelerate the train safely to the desired speed.

vi. Once on the move adjust the controller to maintain a safe and suitable speed for the train.

vii. Listen to the ‘note’ of the locomotive - all locomotives sound different, but each will have a distinctive sound when it is running well.

1. This sound will vary according to speed and load, but you should become familiar with it and you will then easily identify if something changes.
2. Along with speed and load this sound will also change if wheelslip occurs. Wheelslip occurs when the locomotive wheels slide on the rail, rather than rotating at the exact same speed as the rail on which they are travelling. When wheelslip occurs there is a loss of traction and the train will slow down. The wheels will continue to slip until the cause is dealt with. Causes of wheelslip include:
    a. Railhead conditions, if the rail is wet or perhaps covered in leaves or grease then adhesion is reduced and the amount of power that can be applied is also reduced.
    b. Weight of the train, if a heavy train is being hauled up a gradient or around tight curves then wheelslip can occur.
    c. Abrupt changes in power, turning the power controller up too quickly can cause the wheels to wheelslip even on perfectly dry track.
    d. Sudden increase in load, wheelslip may occur if a vehicle in your train has derailed, or is suffering dragging brakes.
3. How will I know if wheelslip is occurring?
    a. Until you become familiar with your particular locomotive it can be difficult to tell, but there are some clues;
        i. The train slows down even if the controller is turned up further.
        ii. The train comes to a halt with the controller still turned up.
        iii. In each case you should hear a whirring from the motor(s), transmission system, and wheels on the railhead. You will probably ‘feel’ that the locomotive is still trying to move, or move faster than it actually is.
    b. Once you become familiar with your locomotive you will almost certainly recognise that the sound has changed and you will ‘sense’ that the speed of the locomotive does not correspond to the controller setting.
4. How do I avoid wheelslip?
    a. Whatever the cause of wheelslip, the only way to avoid it, or correct it once it occurs, is to reduce the power to the wheels. Back off the power controller and allow the wheels to

rotate at the same speed as the rails are passing. Then, very gradually, turn the controller up again, but back off slightly as soon as you sense wheelslip is restarting.

b. In some cases, you may not be able to overcome wheelslip. If your train is heavy and the conditions have changed you may be forced to stop and ask for assistance.
c. Do not be tempted to continue applying power in the hope that the wheels will suddenly regain grip and get you moving. They almost certainly will not and severe damage can be caused to transmission elements or the wheels themselves.
d. Good locomotive drivers understand how to manage wheelslip or when to seek assistance if this is not possible.

2. Managing the locomotive along the railway

a. Maintain awareness of your surroundings, as explained previously, and ensure that you are driving your locomotive at a safe speed and are confident that you could stop the train safely within the distance you can see ahead.
b. Learn the line, the way that a Battery Electric locomotive responds to the controller can provide feedback to the driver about the track, where there are gradients, up or down, or where tight curves are creating drag.
c. Be aware of the location of other trains on the track, even if you can't see them, be aware of whistle or horn sounds, these can help you identify where other trains are.
d. Learn to understand how much running time you have remaining in your battery(ies). Most locomotives will have some form of monitoring device on the batteries, this might be a bargraph display with different colour elements, or perhaps a digital display providing more information. Batteries, of any type, can be hard to accurately monitor though, the slight drop in voltage that occurs as they discharge can mask how discharged they actually are.
e. Battery Electric locomotives are usually quiet in operation and have no particular smell (unlike exhaust emissions from steam or internal combustion locomotives). If you hear any change in sound, or smell anything unusual - it might sound odd, but you can almost *smell warmth,* take the opportunity as soon as possible to check for either loose parts, or if it is a smell, carefully place the back of your hand against the motor or motors. If they feel warm, but you can hold your hand there, then continue to a safe stop point. If they are too warm to touch then call for assistance from the builder or owner.

3. Bringing your train to a stop

a. Whether you are arriving back at a station, stopping at a signal, or stopping for any other reason, always try to stop your locomotive as smoothly as possible.

b. Use whatever brakes are available and understand how effective they are at different speeds and in different scenarios, some common braking options include:
    i. Regenerative braking, many Battery Electric locomotives will have regenerative braking, in simple terms this reverses the flow of current through the motor and uses this either as waste heat, or to return energy into the battery. In either case regenerative has a couple of characteristics:
        1. Advantages. Regenerative braking works well at most speeds and actually provides excellent anti lock braking, within limits, automatically, even in poor railhead conditions.
        2. Disadvantages. Regenerative braking cannot be used to hold a stationary train and will never bring the locomotive to a complete stop. Regenerative braking can apply stresses to transmission elements that are greater than the accelerating forces, so regular checking of chain tensions and gear wear is essential.
    ii. Manual handbrake. Often these are provided on driving vehicles attached to Battery Electric locomotives, although some locomotives may also have them fitted, these can slow and stop light locomotives, but are less effective with heavier trains. As a driver you should familiarise yourself with these brakes, where fitted, and understand how many wheels are braked, often only a single axle is braked. Manual handbrakes are most effective at low speeds or for holding a locomotive or train when stationary.
    iii. If running your locomotive on a club track, or large garden layout, there may be either air or vacuum train brakes available. These are the best systems to use when driving if available.

Disposal.

Disposal is the railway term for what to do with the locomotive once running has been completed.

Each locomotive will vary on what is specifically required, so the following actions may, or may not be applicable. As always, seek advice from the builder or owner regarding your specific locomotive.

1. **Taking the locomotive out of service**.
    a. Ideally, before your battery(ies) are completely discharged, plan to bring your locomotive out of service in a managed way.
    b. Ideally, take your locomotive to a siding or remote section of track to perform the disposal.
    c. Isolate the battery(ies) using the isolator switch.
    d. The locomotive should be cleaned before putting away, particularly if it has become particularly dusty or dirty, or if it is wet.
    e. If the locomotive has been run in the rain then wipe off all surfaces, remove any panels and ensure that as much moisture as possible is removed from these and the locomotive internals.
    f. Perform a visual check of the transmission, look for any change in chain tensions, or debris in gear teeth, etc.
    g. If required, carefully disconnect the batteries and put to one side for separate storage or transportation.
    h. As soon as possible put the separate battery(ies) on charge, or connect the locomotive to a suitable battery charger.
    i. The charging location should be away from other types of loco due to things such as spark risk to petrol locomotives or the ignition of charging fumes from stray embers from coal-fired locos.
    j. Ensure the hand controller is disconnected and stored safely.

Questions for the candidate to consider ahead of assessment on this module.

Question 1

Where is the greatest element of risk within a Battery Electric locomotive?

Why is this element the greatest risk?

Can you describe some risks from this element?

Expected answers

The greatest element of risk within a Battery Electric locomotive is the battery(ies).

The battery(ies) are the greatest risk because they store all the energy that the locomotive will use during the running session, if this is released in an uncontrolled manner (perhaps by short circuit) it can cause injury.

Some of the risks from the battery(ies), include:

- *Risk of explosion, fire or burns from direct short circuiting of the terminals*
- *Risk of explosion from connection or disconnection of charging leads from a battery due to presence of Hydrogen gas.*
- *Arcing, sparking or overheating of connections if these are not suitably tightened*
- *Risk of burns from acid spills (much reduced in modern battery types)*

Question 2

How can I ensure maximum reliability and running capacity from a Battery Electric locomotive?

Expected answers:

Maintenance of the battery(ies) is important, ensure that batteries are kept charged between and immediately after running sessions.
Use a multi-stage charger to ensure the battery is charged completely, within expected parameters, and that if left on charge between uses, the charger maintains a suitable trickle or float current.

Maintaining the locomotive is also important, specifically, ensure that all electrical connections are sound and kept tightened.
Check all wiring, particularly where it is subject to flexing or potential chafing where it passes through holes or between panels.
Check that all transmission elements are maintained, e.g.: chain tensions, gear teeth clean, any lubricating points kept lubricated.
Driving practices, use the controller gently, avoid wheelslip as far as possible, consider using regenerative braking on downhill sections to recharge the battery while running.

Notes.
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