

Steam Driver's Manual

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Introduction

This manual is intended to introduce Junior Engineers into driving Steam Locomotives as part of the 7¼" Society Junior Training Gold Award. You are assumed to have achieved the Bronze and Silver Awards.

Thanks are due to Peter Evans from whose guide this was developed and to the many other people, particularly Trevor Carter, who helped develop these notes further.

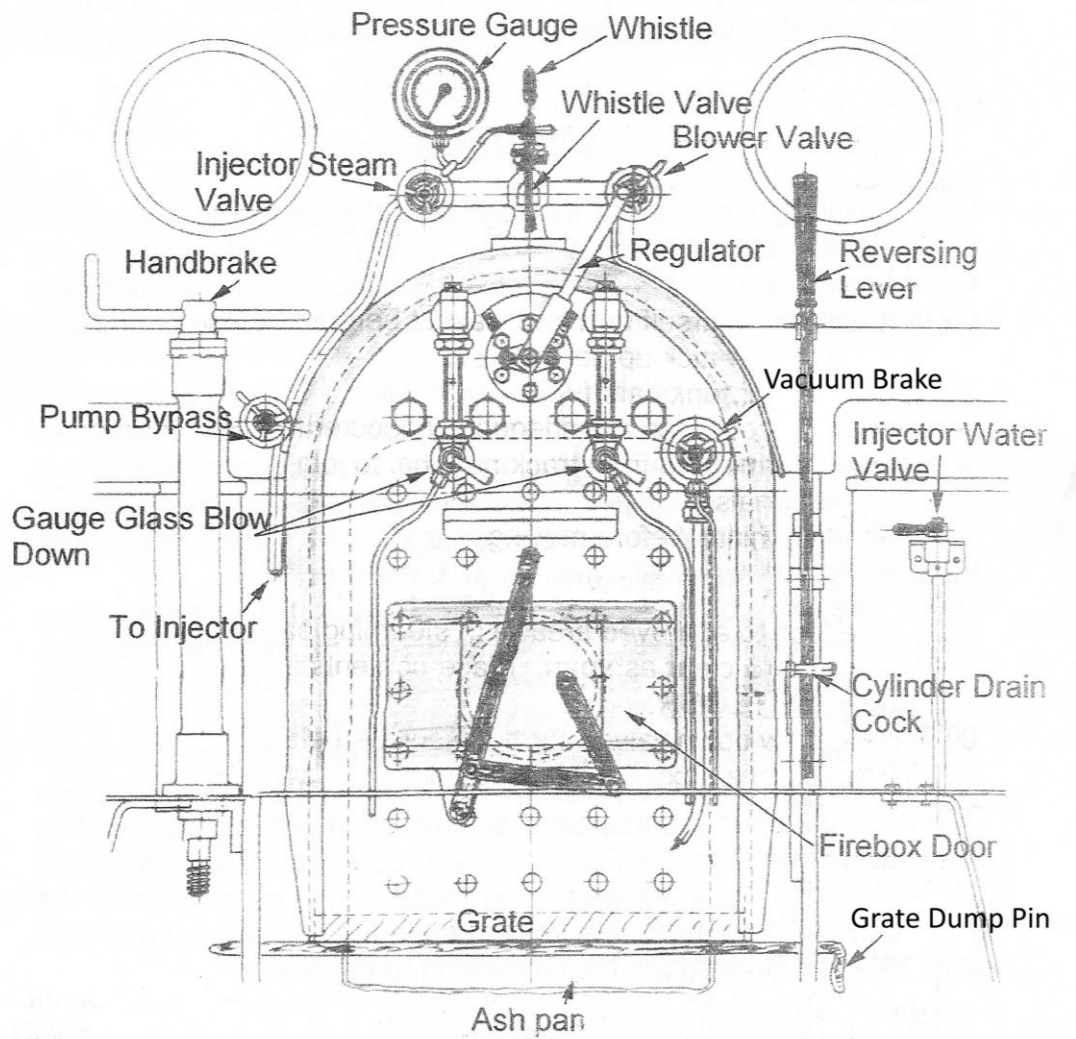
Before we ever think of lighting that fire, there are many things that need to be understood and things to put in place. Firstly you need to be sure you have the appropriate boiler certificates and insurance. This will be covered in detail in another module.

The boiler is only a means of transferring heat to the water, to make steam, just to make the loco move. The heat is generated by the fire, which boils the water into steam. In doing this, it constantly uses up the water in the boiler, especially when the loco is running, so this has to be replenished at the same rate as you are making the steam. The fire also has to be kept going as well. Get any of these things slightly wrong, then trouble is about to catch up with you fast. Too big a fire, you will make more steam than you can use, then you will have the safety valves blowing. This is a waste of steam, fire and water. This loss of steam has to be replenished with cold water which then lowers the pressure.

Importantly, water must be kept at a constant level, ideally half way up the gauge glass at all times. Too high a water level and you will have trouble, too low a water level and you will have trouble, expensive trouble.

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Engine Familiarisation



This shows typical back head (what the driver will see from the driving position). Of course all types of loco foot plate are different, but most of the components shown here will be present. Familiarise yourself with what things are and what they do, on your own locomotive. The key elements are (and you should have most of these):

- Safety Valve, often 2 of these (not shown)
- Gauge Glass, also called Sight Glass shows the level of water in the boiler, see “Water, Water”
- The Grate supports the fire above the ash pan, allowing air into the fire. The Grate Dump Pin allows the fire to be dumped, but this is not fitted on all engines.
- The Fire Box door seals the fire box restricting the air flow. The lever shown opens a split door, warning it gets hot! On marine boiler the doors are usually hinged.
- The Injector is used to force water into the boiler as does an axle pump, see “But how does the Water...”
- The Reversing Lever puts the train into Forward or Reverse “Gear” and limits the travel to give efficient use of steam. Of course no gears are actually involved, see “No Gears?”
- Handbrake- screwed down it locks the brakes on.

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- The Whistle Valve works the whistle. The location and operation of the whistle varies widely between different locomotives, some use a chain to work the valve.
- Ash pan and grate removal procedure. These are removed backwards on marine boilers
- The steam Blower operation uses steam to draw a draught through the fire, the smoke box door has to be shut tight, otherwise you will never get any draught through the fire.
- The lubricator puts oil into the steam supply to lubricate the valves and the pistons, you also need to know the location of all the lubrication points on the motion.

Equipment/Tools

1. Water/wood/fire lighters/coal + matches.
2. Steam oil, lubricating oil & oil can
3. Flue brush
4. Tools, including a coal shovel and fire iron or rake
5. Blower and battery
6. Gloves and glasses or some type of eye protection.

Water, water, everywhere

The **Gauge Glass** or **Sight Glass** is installed to enable the driver to maintain the water level so that the fire box crown is **NEVER** uncovered in operation. Mid way up the glass is the ideal level for most purposes, e.g. starting your fire, starting running. Do not overfill the boiler either.

The **Gauge Glass Blowdown Valve** uses the boiler steam to blow the water out of the gauge glass and ensure the water level is reading correctly. The water must return rapidly after closing the valve, otherwise you should suspect a blockage in the boiler fittings.

If the water is so low you can't see it, rocking the engine may show water is there, just below the bottom nut – get some water in fast. The bottom nut is usually positioned just above the fire box crown.

If the glass is completely full it may also look empty. Good practice is to use a black and white, diagonal stripe pattern behind the Gauge Glass on a piece of card or metal. This shows the lines as vertical where water present, so if the glass is completely full, you can see it. Too much water and you are likely to get scalding hot water spurting from the safety valves, or into the cylinders and up the chimney when running.

Getting water in the cylinders cause them to **Hydraulic** and can damage them.

Starting

1. Check in with Track Marshal/Station Master.
2. Only start in an approved area (e.g. steaming bay)
3. Fill water (boiler and tanks) including water treatment in to the boiler, if used.
4. Fill lubricators.

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5. Check smoke box door is closed.
6. Check ash pan and grate is secured in place.
7. Check how you dump the grate in an emergency.
8. Light fire.
9. Lubricate all motion.
10. Check everything is operational that should be, i.e. gauge glasses, injectors, vacuum system, safety valves.
11. Check your electric blower fits without falling off, has a good seal to the chimney and is operational.
12. Check that all flexible hoses are properly fitted so that air cannot be drawn in to the injector or pump

Fire Box

Grate: This supports the fire, allowing air to flow from below to help the coal to burn. It also allows residue of the burnt coal, the ash to fall through to keep the fire clean. A clean fire burns well and is less likely to produce **Clinker** (fused lumps of material). Clinker will smother a fire if it builds up by blocking the grate.

Ash Pan: This collects the fire ash and stops it dropping on the sleepers.

Removing: The means for supporting the grate and ash pan vary from one model to another but a common means for removal is to pull a pin sideways through the engine frame. On marine boilers the grate and ash pan are removed backwards by undoing nuts on studs on the back-head.

Raking Out clinker: The build-up of clinker is reduced by regular raking of the fire to make the ash drop into the ash pan. If ash is allowed to remain in a hot fire it will be free to form clinker. The fire iron (rake) should be pushed in through the firebox door and worked backwards and forwards in contact with the grate to make the ash go through the bars. If clinker does develop it can be brought to the top of the fire with the iron and removed through the firebox door.

There are many methods to fill an empty boiler from scratch. Different people will use different methods. You can remove a safety valve on a loco, (not a traction engine though) and fill it from there. Many people use the boiler blowdown valve. You could use the loco's own hand pump to fill it off its own tanks, but this is only practical for smaller locomotives. You can remove one of the clack or bypass pipes and pump it in through there by using a small electric pump. Whatever method you use to fill the boiler, always do it, to half way up the glass. Do not over fill it, as that can get you scalded, as lots of very hot water can come up the chimney.

Leaving the smoke box door not properly shut is quite easy and I suggest that when you open it, you always get into the habit of fully closing it again. Better people than you, have been caught out on this, both model and full size!!

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When oiling up always be on the lookout for loose nuts and bolts as you check round. There are also certain items that you need at the ready. Before you start lighting the fire it is a good plan to check the length of the firebox that you are about to load.

Firing up

Before we light the fire up, assuming that we now have water level correct, then check that:

- All the bearings on the loco are oiled up. Don't forget the axle boxes and if fitted the eccentrics
- the Hand Brake is on,
- the Reversing Lever in mid gear
- the Regulator is closed.
- the Lubricators are filled with steam oil
- the Grate and Ash Pan are in and are secure
- the Smoke Box door is tightly shut
- that Fire Regulator or Damper is closed
- the Cylinder Drain Cocks are open

Why are they so oily?

As most of the working part on a steam locomotive are external they need constant lubrication. Some parts are automatically lubricated, you just fill the lubricator oil chest and check it's working.

Lubricators: Check that the lubricators are filled with steam oil, either mechanical or hydrostatic type. For a hydrostatic type you will also need to drain any condensed water. Never use any other type of oil in steam cylinder lubricators other than steam oil.

Motion what does lubricating and how do you do it?

Some builders use "Sealed for Life" ball races which do not need to be lubricated. More usually bearings are bronze bushes lubricated by oil cups filled before running and maybe topped up whilst running

Oil types

Oil in the water or **Water Treatments**: This is a difficult subject, depending on the hardness of your water and your boiler type. Ask around locally for advice.

There are lots of different methods to start the fire. Some use oil or paraffin soaked rag or wool, then wood. Some use a commercial fire lighter then wood. Some use paraffin soaked wood or charcoal. The choice is yours, but as soon as the fire is lit, put on the electric blower, do not however be too quick in putting on the coal, get a good wood or charcoal fire established first. It is imperative that the fire is totally covering the grate area. Any holes will wreck the steaming qualities.

idea to have an experienced driver with you to point you in the right direction, for the first few times you will encounter loads of problems mostly of your own making. The fire will go out that sort of thing. Do not be deterred, this is often normal until you gain experience. Things soon will become second nature but having somebody that is used to this, will help you a lot.

When you have a good fire going, pressure will start to slowly rise. Wait until you have about 20-40psi on the gauge then take off the electric blower, you can then turn on the locos own steam

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blower. Do this too early, then you will use up all available steam, and the pressure will then not rise. The actual pressure you take the blower off will depend on your loco, it's probably best to err on the high side until you have more experience of your loco.

Fire, fire burning bright.

Any fire needs a draught through the grate to make the fire burn. In a domestic grate at home, there is a large chimney to create this for you. In small scale locos this draught is very poor and needs help. So you use an electric blower to create a draught to get the fire to start. When you swap this over to the loco's own blower, this does exactly the same by just blasting steam up the chimney, which causes a draught to be drawn through the grate.

Similarly when the train is in motion, the exhaust steam from the cylinders sent up the chimney causes the draught through the fire.

When you are stationary that draught stops, so that is the reason you have to put the steam blower on, just to maintain the draught to keep the fire bright when the loco is stationary. Normally the steam blower only needs to be cracked on to maintain a good head of steam whilst stationary.

All of these require the smoke box door to be shut tight and sealing well.

Using the right quality and size of coal is also essential. Your Club will usually supply coal in various sizes. Talking to other club members will help you choose coal of the right size and type.

Spark Arrestor: Spark arrestors or spark deflectors are design to stop sparks from the fire from falling on the driver or any passengers behind.

Pre running checks

Keep the fire stoked up, also keep checking that water level. Check the cylinder drain cocks are open, make sure that the reversing lever is in mid gear, then crack open the regulator. This will admit some steam to the cylinders and warm them up with any condensate draining off through the open drain cocks. Watch that water level constantly and add more if it is required by any of the means at your disposal.

Try the water gauge blow down. This is just to make sure that the water level is correct and the glass is clear. They have been known to give a false reading, by blocking up if not blown down regularly and the level should return quickly when the blow down valve is closed. The water level must not go below the bottom nut. As pressure gets to 50psi shut down the blower a bit and check the fire.

Safety has to be paramount, it is always a requirement and it is assumed that you will have read the club safety codes and track rules. You will sometimes have to sign a document to say that you have done this, before steaming starts. These are normally common sense like speed restrictions and track marshal identity. Emergency procedures, safe practices, signalling, track layout, water pick up points etc. will also apply.

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Running

If there is a Track Marshall in residence on your track, it is essential you seek his permission before you move. Failure to do that could well terminate your run before you start. Remember he is there to make sure everything runs safely, so obey his instructions at all times. There may of course be signals to tell you as well.

It is a good idea to learn to blow the whistle whenever you move off, as it warns everybody that you are about to move. With the reversing lever fully forward, if you now slowly open the regulator some more, the train should start to move.

With mechanical lubricators the oil will flow, when you move. With Hydrostatic ones, you will have to open the sight glass steam cock to regulate the flow and make it work. Check for bubbles of oil passing through the water which show it's working.

As the loco gathers pace you can close the cylinder drain cocks. Keep the speed to approximately a very slow walking pace, certainly until you get more confidence. Check water regularly. When on the move, you can put water in the boiler by closing the bypass to let the axle pump, if one is fitted, do this work for you. Always aim for half a glass of water, when it gets to that level open the bypass and no more will go in until you close it again. If for any reason you cannot see the water level in the glass, put in water immediately. Also try the gauge glass blow down tap. If you cannot restore the water level very quickly - DUMP THE FIRE NOW, DO NOT DELAY. You are in a very dangerous situation.

If however all is normal, check the fire, always remember that it is often better to put a little coal on often, rather than a lot with longer intervals. If pressure is rising fast, to save blowing off safety valves and wasting steam, you could put in cold water or close the ash pan damper, if one is fitted or just open the fire box door. Any of these will usually lower the pressure for a bit, also adding coal will lower the pressure as well.

But how does the Water...

There are 3 methods to get water into your boiler **when it's under pressure.**

Injector uses steam to force water into your boiler. The injector/water should be cold for it to work best. You may see someone using a watering can to cool it, to get it going. Injectors are akin to magic (any technology that is sufficiently advanced appears to be magic).

You feed water into the injector first via the **Injector Water Valve**. Water should be and can be seen running out of the injector. Then you turn the **Injector Steam Valve** slowly and the water should stop flowing, a sign it is going into the boiler. Some injectors work better at low pressure, some at high pressure, depending on the design. Having one of each is a common arrangement, see [REFERENCE TO MORE ADVANCED GUIDE TO INJECTORS HERE](#).

Axle Pump – run off an eccentric on an axle. It only works when the locomotive is in motion. It can overfill your boiler, hence the **Pump Bypass valve** which returns the water to your tank when opened.

Hand Pump – a lever operated pump used to pump water into the boiler, more common in smaller gauge engines, too much work for larger 7¼ locomotives, good backup if your injector is playing up.

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Do not race about the track because that is when trouble starts. On any locomotive model, speed should never be allowed to get too fast, as a guide 8mph (approximately jogging speed) is too fast in most people's eyes. Never enter a station or cross points at speed, always use caution at these places. It is a good plan to always learn to look at the points before you cross them, just to make sure they are set correctly. This can often save you a lot of embarrassment in later years.

It is also a good idea to try the brakes on your driving truck to see if you can stop, do this at an early stage of your run. That way you get a good idea how far it takes you to stop if there was an emergency. I can assure you it is often a lot longer than you would expect. Track conditions also make a big difference to the stopping distances, wet or dry track and also steel or aluminium rail make a difference; that is without taking any gradients into the equation. That is the reason you should try it, as every track is different. Hopefully an emergency stop will never be needed.

When you wish to stop normally, just close the regulator, and apply the drivers truck brake and/or the vacuum brakes. When stationary, open the drain cocks and apply the engine brake. Put the reversing lever into mid gear and turn on the steam blower a little.

So how do I stop?

Hand Brake - this operates the brake on the locomotive, usually using a winding mechanism and is generally not suitable for stopping your locomotive, it is really a parking brake.

Truck Brake – this operates a brake on the driving truck, generally some sort of lever which is suitable for braking the locomotive, and indeed a train.

Vacuum Brakes – generally used to break an entire train, a vacuum is required for the brakes to be off. This means if a train uncouples, the brakes are applied, because the continuity of the vacuum pipe will be broken.

An **Ejector** is used to produce the vacuum, these are related to Injectors and are covered in [REFERENCE TO MORE ADVANCED GUIDE TO INJECTORS HERE](#).

Whilst we are on the subject of stopping, with some types of regulator they have been known to stick open. Although this is highly unusual, it is as well to know what to do if this ever occurred. If when you closed your regulator the engine still gathers speed, all you need to do is pull the reversing lever to the mid position and apply the brakes. If this does not seem to work fast enough, then pull the lever slowly into reverse.

To get back to stopping normally. When stationary, you will have to open the blower, how much you put this on will just depend on how the pressure is at that time, if rising too much, do not put the blower on fully on, put in water or open the firebox door. If pressure is falling, this is your chance to revive the fire etc., with the blower fully on.

Providing that you can learn to maintain the water level and keep the fire going, then you are doing fine. When stationary always remember have the blower on, reversing lever in mid gear, brake on, drain cocks open.

So to summarise starting off,

- Check for permission to go (track marshal or signals).
- Blower off
- Brakes off
- Reversing lever forward

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- and whistle
- then open the regulator slowly
- shut drain cocks after you have got going

Individual Running

If you are running on the track when not open to the public then it is up to you to be doubly careful. First of all check the track for obstacles or rubbish. Check the points are set correctly. Sign the Track Book to say you have been etc., basically you are not just the driver, but Track Marshal as well. Always make sure that at the end of your run you clear up and put everything away. There are no servants there to do it for you. Make sure all is locked up and correct before you leave. It must be stressed that some club insurance's do not cover you, if it is not a club function. You must obtain private cover for this or at least check this out first at your club.

Closing/Shutting Down

When finishing your run for the day: drop the fire in the appropriate place usually the steaming bay, not on the track. Make sure the water level is correct, before all your steam has gone, shut the lubricator off and use the boiler blow down valve to get rid of any deposits in the boiler.

By opening the blow down valve you will clear the boiler of any unwanted deposits that have accumulated around the foundation ring. If you leave them in place, they set hard like concrete and in time will wreck your boiler. Reasons for this are that deposits interfere with the water circulation and then cause hot spots. Regular blow down usually gets rid of the problem. If you are on hydrostatic lubricators, it is essential to always close the cylinder drain cocks and put plenty of oil into the cylinders, before the lubricators are switched off. This stops cast iron cylinders from rusting. When all the pressure is nearly gone close the lubricator gauge glass cock, open the drain on the lubricator tank to remove the water, then refill with steam oil right to the top again. Never open the lubricator oil tank drain without first shutting the cock on the sight feed glass. If you do not do this, it will drain the fluid out of the sight glass and make a hell of a mess of the glass with oil, You then have to dismantle it all, to clean it and refill with brine etc. Brine stops the oil sticking to the glass.

Clean everything down. Clean out the ash from the smoke box. Do not forget to sweep the boiler tubes as well. Replace the grate which should have cooled by now. Oil round and spray all bright metal with WD40 or similar, to keep them free of rust.

If you are going to leave the loco for some time then drain the water. It is easier to do this when there is some slight pressure in the boiler via the blow down valve. Drain all the water tanks as well, if fitted. Pay particular attention when draining for the winter, to any pipes that fall below your drain pipe. Better to disconnect things like injectors and pressure gauge, or indeed anything that will trap water and freeze. Always leave the valves slightly open. It is always a good idea to keep the loco in a frost free place in the winter as well if at all possible.

At first you will find co-ordinating everything pretty daunting, but after a time, a lot of these things become semi-automatic. If you are at all in doubt about anything, do ask another competent driver as they should certainly not like to see you in any difficulty. Most will be only too pleased to help. The club could if asked, often run help type training courses by a competent driver using your own engine if required. This will enable you to become more confident in the art of driving your own loco in the shortest possible time.

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Running

1. Familiarise yourself with track layout before starting.
2. Identify water pick up points.
3. Check water tanks are full.
4. Check all couplings are adequately secured.
5. Obtain permission from track marshal to join the track.
6. Check signals.
7. Operate whistle before moving.

Closing Down

1. Take loco to approved area (e.g. steaming bay)
2. Dump fire & clear ash pan. Place contents in approved facility, NOT THE FLOOR.
3. Open blow down valve when pressure is below 30psi.
4. Clean smoke box
5. Brush tubes, if not too hot
6. Clean spark arrester
7. Refill lubricators
8. Lubricate all motion work
9. Spray bright metal parts with WD 40
10. Check round the engine noting any defects to be rectified before the next run.
11. Tidy the steam raising area, clear ashes stow equipment. There are no servants available.

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As a final comment. Always remember that you are driving a potentially dangerous vehicle. Never mind the passengers, you are the first it will injure. Provided you have plenty of water in the boiler and the safety valves are set correctly and working, it is perfectly safe. If ever you do get into trouble, act quickly and dump the fire. Then sort everything out and re light. Safety should always be paramount in your mind. I would stress on a point that was experienced just lately. If a regulator stuck open for any reason always pull the reversing lever to mid gear immediately. This will remove steam and power from entering the cylinders and will enable you to a stop. Provided you know the problems that you could encounter when driving, you will I am quite sure have very little trouble.

Now some do's and don'ts:

Do not run any engine low on water, it is just as easy to run with it high in the glass as to run with it low down the glass. Running it low is very dangerous!!!! Running it too full at the top of the glass can over fill the boiler which when you open the regulator can send boiling water up the chimney and all over you. This is called **priming**.

Never try to force the fire when starting up by raising the temperature of your boiler from cold too fast. This just puts a load of stress on the joints and tubes. Some people will put their 12 volt blower on 24 volts just to do that. All that does is strain the boiler for no good reason. New boilers are very expensive so why push your luck.

Do not put coal on the fire when the engine is stationary **without** first putting on the blower. Reason for this is simple, if you do not create a draught when you put coal on, often when you open the fire box door, there can be a large flame emitted. You can easily get burnt and will certainly loose quite a bit of hair, if you are close to the back head. A bit of draught created via the engines blower and the problem goes away.

Always remember that speed although fun, is highly dangerous. If you are on your own, try using a mark on the track as a point, then try an emergency stop when travelling at say 6mph. You will be amazed how far you travel before stopping. That is just you, not a train load. That is the reason to keep your speed to well under 6 mph, let's hope you never have to have an emergency stop for real, but better safe than sorry. When carrying passengers always keep your speed down for safety reasons. It also gives them a longer run.

As regards stopping always remember even with the regulator open if you put the loco in mid gear it should stop. This is subject to the valve gear being normal, if abnormal go slowly into reverse that will do the trick.

Always test the injector, vacuum, sight glasses and safety valves before you start your run, just to make sure they are working ok. Good idea to test your truck brakes at the same time. Some clubs will require you to do a brake test when you first go out on the track.

Never run without proper pin sin all the links between all trucks with safety pins in them to stop them coming out unannounced. Some clubs require extra safety chains as well.

As regards couplings between loco and driver's truck and passenger trucks couplings, they need to be good. Solid bars are excellent but so long as whatever you have in place is strong and safe that is fine.

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Never be afraid to admit you have a problem and have to dump the fire. Better to do just that, than have a major problem. You can always relight the fire again. The alternative can often be a very expensive boiler replacement.

Also remember when raising steam from cold it is not a race. Better to do it nice and steady, than force the fire too much. All that does is cause leaks later on in the boilers life. Some drivers like to raise 20/30 PSI of steam using wood or charcoal only, before getting on any coal, so that they have by then removed their electric blower and are using the engines own blower. There are merits in this idea, but it is up to each individual's choice.

It is a good idea to get into the habit of sounding your steam whistle every time you start off. Also when you stop and apply the brakes always put the reversing lever into mid gear. The reasons for this is that people always know you are about start when you whistle. Regarding going into mid gear, the regulator were to be knocked for any reason, like with your shovel when putting coal on, then the train would not move until you wanted it to if the lever is in mid gear.

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SAMPLE QUESTIONS

Criteria for driver competence

This is not meant to be a third degree exam. The club has to make sure for club insurance purposes, that you are competent to be in charge of any locomotive carrying the general public. This test is coupled to your being able to keep a locomotive working safely for a prolonged period.

1. When coupling up to train what would expect to be present when you had completed the task?
2. What would you do if you suddenly found that for some reason you had a major problem when out on the track?
3. If after some time of running, one of your train of two trucks derailed due to kids larking about or some other reason, what would you do?
4. Let's assume that you had been running for some time and there was another train with you somewhere on the track. You are confronted with a small loose dog sitting near the track. What would your plan of action be?
5. What is the safe and recommended speed to run at on the Model Engineering Society track when there are passengers present?
6. There is a Track Marshal / signal man on duty, but there are no signals working, just at that moment you cannot see him. Your train is loaded and ready to depart, the track in front of you looks clear, what do you do?
7. What information would you require, when taking control of somebody else's engine?
8. When you wish to come off the track what is the proper procedure when there are others running?
9. In an emergency what is the procedure?
10. What would you estimate the stopping distance for your loco and driver to be from a speed of about 10mph?
11. When passengers are present when is it safe to proceed if no guard is available?

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SAMPLE ANSWERS TO THE ABOVE-QUESTIONS

1. A solid bar coupling with cotters of some sort underneath the pins to retain them on all trucks. A safety chain coupled up between all trucks as well, Brakes coupled as well if they are present.
2. Stop at once and blow air horn or whistle for a minimum of 5 seconds.
3. Stop immediately, sound air horn or whistle for a minimum of 5 seconds plus send guard or a responsible person back along the track to warn the following train, Notify the Signal man or Marshall, always protect the rear of your train.
4. Stop the train sound the horn to warn others there is something wrong. Do not proceed until the animal has been removed off site.
5. A max of 6 mph but officially less.
6. Wait until he comes back.
7. Operation of brakes. Location controls, valves and air horn. General condition of engine and train couplings.
8. Inform the Signal man / Marshal and await THEIR instructions.
9. Stop and sound your air horn or whistle a minimum of 5 seconds, Keep the passengers seated.
10. It is quite a distance. Probably a lot more than you would ever think. More to the point you should never be going that fast to find out, as there is a 6 mph limit on the track. Speed limits vary from one track to another.
11. When you are signalled and told to proceed, if you have more than one truck you may not proceed until the guard is present. To go would mean you have no insurance.
12. At some Model Engineering Societies it is imperative that air horns must be present on all trains to be sounded in an emergency. COLLECT AT THE SIGNAL BOX BEFORE STARTING. One long blast of at least 5 seconds means all trains stop immediately. Two short blasts means proceed with caution. Some clubs have other arrangement like whistle long and clear. The guard is responsible to go back and warn on-coming traffic anyway.