

North Wales Model Engineering Society.

How to prepare and drive a miniature locomotive.

February 2006.

Introduction.

Driving a miniature locomotive is just like driving a full size one with all the same responsibilities, but you are the fireman as well as the driver. You are also responsible for the safe operation of the train

Operational Safety

The Health and Safety Executive Guidance HSG216, on the Operation of Passenger Carrying Miniature Railways, states, among other things, the following:-

- 1 *Miniature railways need to ensure that all staff involved are competent for the duties they are to perform, (Operations, Para 87.)*
- 2 *A visual inspection of any locomotive should be made before it is used. In the case of a steam locomotive, a further inspection needs to be made during steam raising to look for any leaks or failures. This latter inspection needs to include the checking of water feeds, blowing down the water gauge(s) and observing the correct operation of the safety valve(s). In all cases, the inspection should include the testing of the audible warning device and any braking system. Any defects found in these items should be remedied before the locomotive is used. (Operations, Para. 106)*
- 3 *Drivers are responsible for ensuring their locomotive or train is under control at all times and, in cases where no guard is carried, are responsible for the safety of passengers.(Operations - Para. 101).*

Prior to operations commencing an inspection of the Track, Carriages and couplings must be carried out to ensure that they are safe to use. A form must be completed of this inspection such as below.

I have personally inspected the running track today, removed any debris, and observed no obvious defects, which prohibit the safe running of locomotives and trollies.

Signed

Date

I have inspected all trollies and couplings and am satisfied that they can operate in a safe manner.

Signed

Date

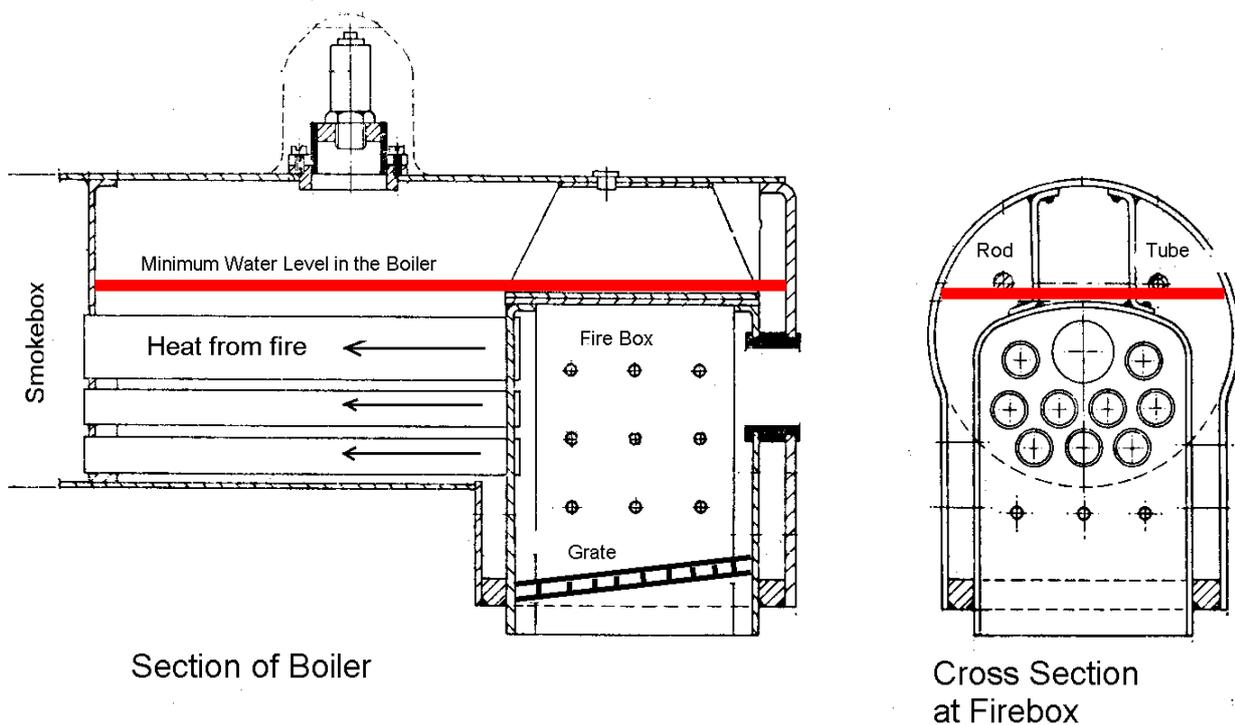
The other thing to ensure before raising steam on a locomotive is that it has a current boiler certificate. (If this is issued by a club/society, then the owner's membership needs to be up to date or the boiler certificate is not valid.)

Note: - All copper boilers must be tested every 4 years.

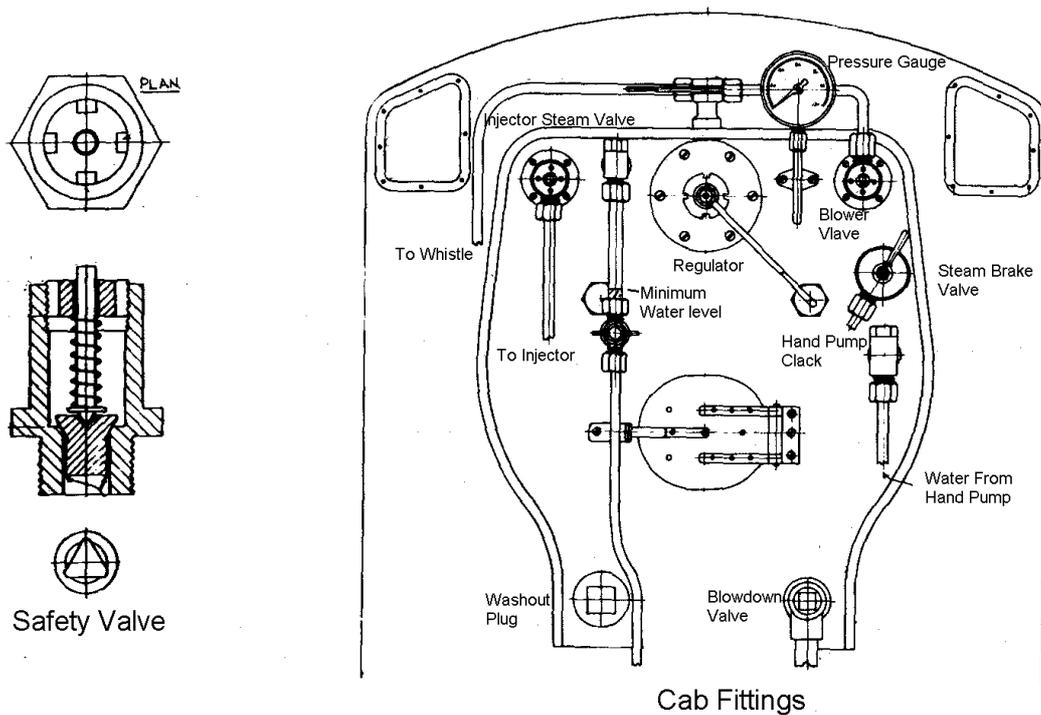
They have a hydraulic test at 1.5 times the working pressure followed by a steam test at working pressure to check the safety valve operation. The pressure gauge must be marked with a red line to indicate the working pressure. The pressure gauge is calibrated against a master gauge during the hydraulic test. There is an annual test to check the operation of the pressure gauge, safety valves, water pumps and injectors.

Components of a Locomotive

The Boiler.

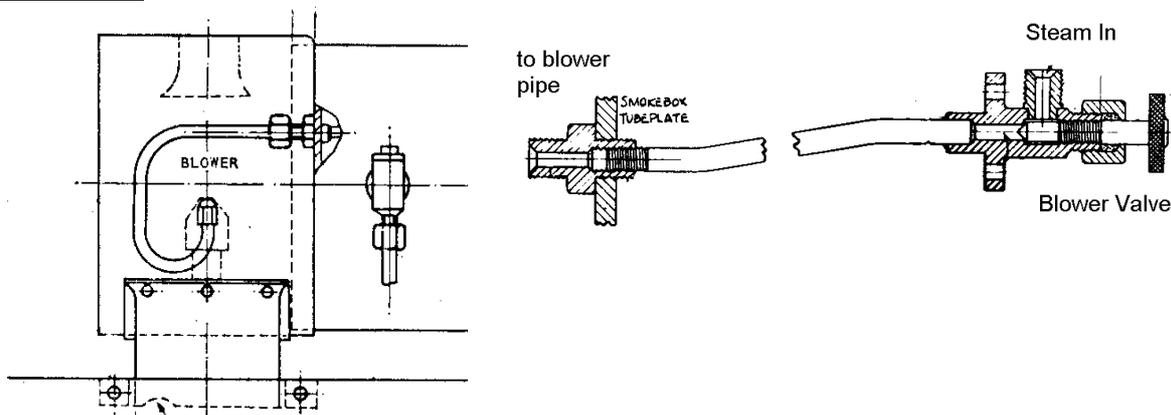


Here we see a section of a typical locomotive boiler. The **MOST IMPORTANT** point to note is the line shown as the “Minimum Water Level in the Boiler”. The main thing for any driver to remember is that this must be maintained at all times whenever there is a fire in the Firebox. It does not matter if the fire goes out, but if the water level drops below the top of the firebox there is a risk that the boiler could explode if the locomotive is moved as the safety valve could not cope with the amount of steam produced as the water moves back onto the hot firebox top. Remember the fire is at a temperature of about 1600 degrees and water boils at 100 degrees. The water level is shown by the Water Gauge on the backhead of the boiler. Some boilers do have a fusible plug in the top of the firebox, which will melt and release the boiler steam into the firebox and put out the fire, but not all boilers have this safety feature. The locomotive can not be used thereafter until the fusible plug is repaired or replaced, which is a few hours job.



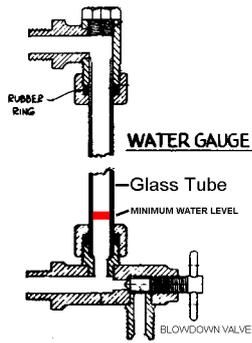
Here we see the typical backhead of a locomotive and the various boiler fittings. Not all fittings will necessarily be provided, or be in the same place. It is up to the driver to familiarise himself with the location of the fittings of each locomotive. In particular the regulator will sometimes open clockwise on one locomotive but anti-clockwise on another or even be pull/push type.

The Blower.



The Blower is needed to keep the fire burning properly whenever the locomotive is stationary. It may also be advisable to have the blower on slightly on an “up and down” track as the exhaust from the cylinders may not be enough to keep the fire burning properly. The blower feeds steam to a jet which blows up the chimney, this draws the heat from the fire through the boiler tubes and so makes more steam in the boiler. It also draws air through the fire, which is needed to keep the coal burning in the firebox. The blower is adjusted so that the fire is kept burning but the safety valves do not blow off excessively.

Water Gauge.



The Water Gauge is the most important fitting on a steam locomotive. It reads the water level inside the boiler. The water level **MUST NEVER** be allowed to drop below the top of the nut at the bottom whenever there is a fire in the firebox because there is a risk of a boiler explosion as the water surges over the top of the hot firebox top (see above, The Boiler)

Pressure Gauge.

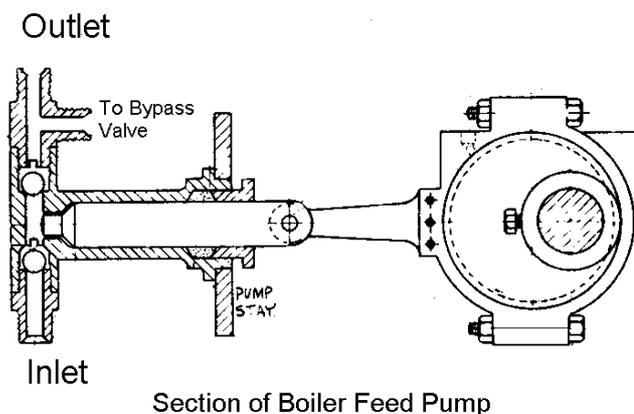


This gauge indicates the steam pressure inside the boiler in pounds per square inch.

The gauge must be marked with a red line, which is the normal maximum working pressure. The safety valve should start blowing off when this pressure is indicated.

The gauge is calibrated during the boiler hydraulic test and is checked for calibration against a master gauge. The gauge may not accurately read the value for the working pressure stated on the boiler certificate but the red line will be the calibration mark against the master gauge. Should the gauge not read the correct value when the safety valve's start to blow, the gauge must be suspect. **THE SAFETY VALVES MUST NEVER BE ADJUSTED.** The fire must be dropped and the gauge must be rechecked against the master gauge before the locomotive is used.

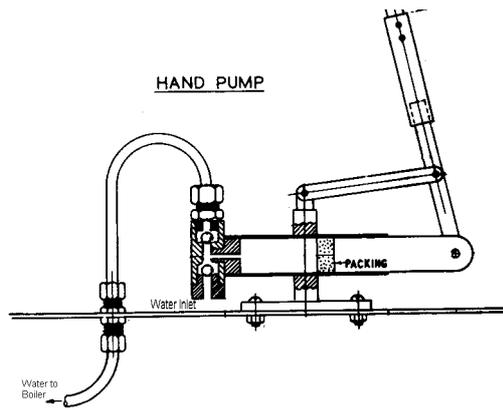
Axle Pump.



The Axle Pump pumps water into the boiler whenever the locomotive moves to replenish the water used in making steam to drive the locomotive. The water feed to the pump is direct from the water tank and has no valve. The outlet feeds the boiler via a non-return valve, the amount of feed being controlled by a bypass valve fitted to the pump,

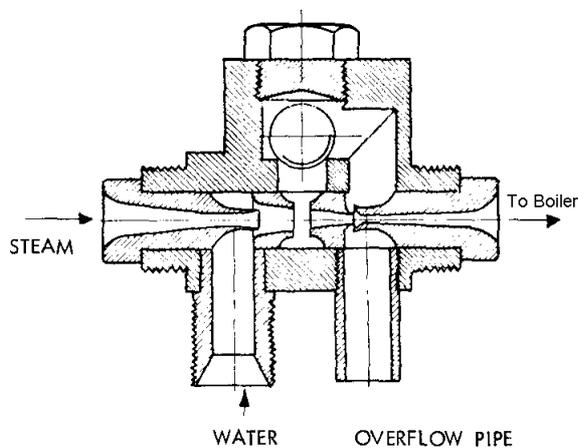
which can feed some of the water back to the storage tank. The bypass is normally adjusted to keep the water level in the Water Gauge at about mid way up the glass. On an "up and down" line the bypass may need to be left shut, as the amount of water fed into the boiler is not excessive.

Hand Pump.



The Hand Pump is used to pump water into the boiler when the locomotive is stationary. It feeds the water into the boiler via a non-return valve. The Hand Pump is operated until the water level is over halfway in the Water Gauge glass. It may need to be used frequently while waiting for passengers for the train.

Injector.



Some locomotives are fitted with an injector. This is a device, which will feed water into the boiler. It uses steam from the boiler to force water back into the boiler. The method of operation is as follows, the water is turned on until a steady stream flows out of the overflow pipe, the steam valve is then opened fully and the water flow from the overflow will reduce and a singing noise be heard as the injector puts water into the boiler. The

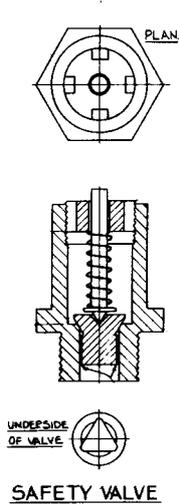
blower must be on at this time to keep the steam supply up as cold water is being injected into the boiler. The injector will put water into the boiler at a good rate so keep an eye on the Water Gauge glass or the boiler will be overfilled. To turn the injector off, the steam valve is shut and then the water valve.

If when putting the steam on for the injector, steam comes out of the overflow pipe, the water is probably warm from the tank and the hand pump will have to be used instead.

Regulator.

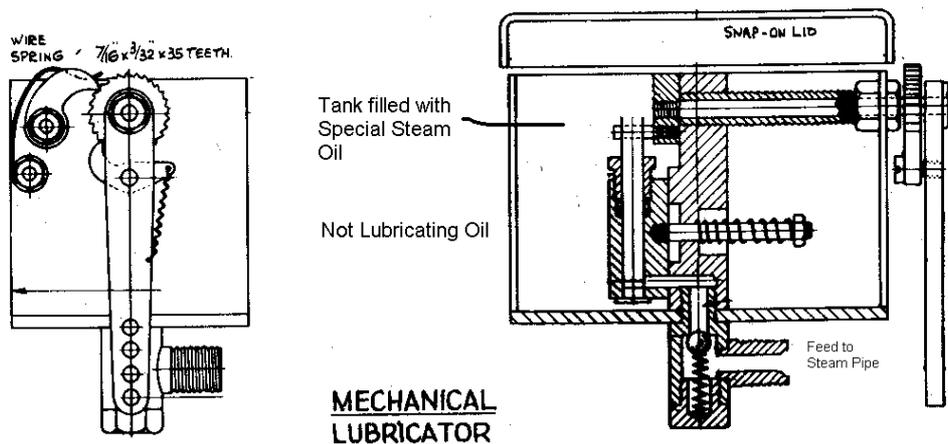
The regulator is a valve that will regulate the steam supply from the boiler to the cylinders to drive the locomotive. The regulator must be opened slowly or the wheels will spin on the track as the locomotive starts moving. As we stated earlier on some locomotives the regulator is opened clockwise and on others anti-clockwise, or even pull/push on some locomotives. If the wheels do spin on the track a shower of sparks could be emitted from the chimney due to the blast from the steam exhaust up the chimney. Hence the need that a "spark arrestor" is fitted to the chimney to prevent burns to people.

Safety Valve.



The Safety Valve is the protection device for the locomotive to stop the boiler pressure going over the design working pressure. The Safety Valve must **NEVER** be adjusted without a master test gauge connected to the boiler and in the presence of a Boiler Inspector. As stated above, the Pressure Gauge is an indicator of the boiler pressure not necessarily a correct reading. The Safety Valve will open when the set pressure is reached and shut again when the boiler pressure drops. If the Safety Valve emits wisps of steam after shutting do not attempt to stop it by tapping the pintle at the top of the valve, it is probably that the valve is starting to scale up and needs cleaning. Putting a few drops of oil into the top of the valve at the end of a days steaming can reduce this problem.

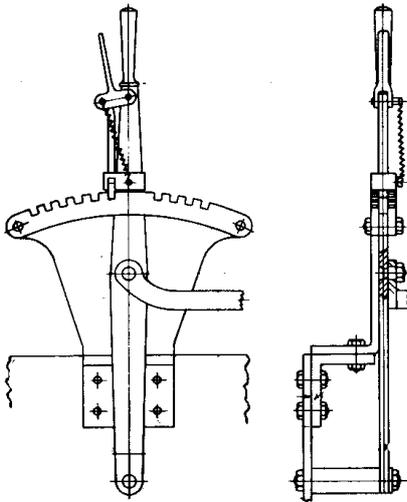
Lubricator.



The lubricator is a device that slowly feeds oil into the cylinders as the locomotive is run. There is no adjustment to the amount of feed as this is built into the design. A sign that the lubricator is working is an oily film at the top of the chimney. Only special steam oil must be used in the lubricator, other types of oil will not lubricate the cylinders and they will wear. Checks on the lubricator are that the ratchet device clicks or the clutch device move the lubricator shaft a small amount for every revolution of the driving wheels and that the oil remains dark, a milky looking oil means that the lubricator is not working. Steam is bypassing the non-return valve and the fault must be repaired before the locomotive is further used.

There is also a type of lubricator known as a Displacement Lubricator. This type has no moving parts and is filled by removing the top cap, injecting steam oil to fill it and then replacing the cap. The lubricator has to be drained of condensed water by removing the cap, opening a valve at the bottom to drain, shutting the valve and then refilling with oil.

Reversing Lever

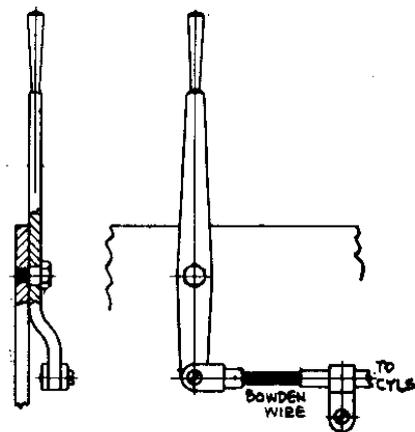
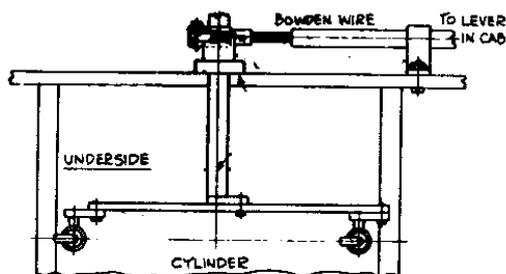
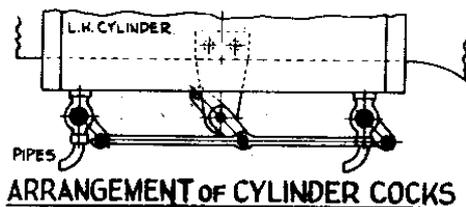


REVERSING LEVER

This is the means by which the locomotive drives forward or reverse. On an up and down track the lever is moved either fully forward or fully back depending on the direction you wish to go. The lever is only moved after the locomotive has come to a stop, never when it is moving on an “up and down” track.

Note: - there is also a screw type reverser fitted to some locomotives which serves the same purpose.

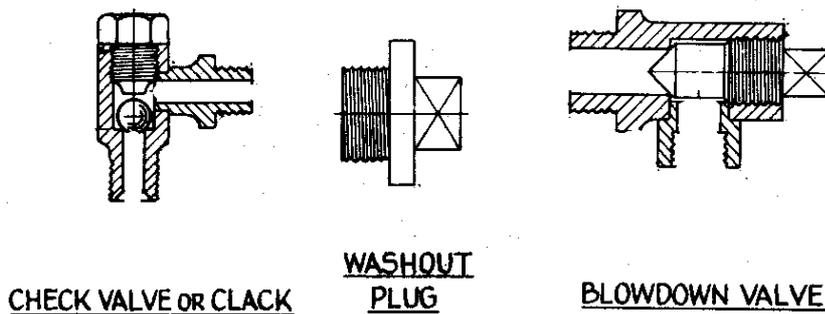
Cylinder Drain Cocks



LEVER FOR OPERATING DRAIN COCKS

The Cylinder Drain Cocks are used when first starting to move a locomotive. When steam is admitted into the cylinders for the first time, the cylinders are cold and the steam condenses back into water. This water cannot easily get out of the cylinders so the locomotive effectively locks up. By opening the drain cocks the water can get out of the bottom of the cylinders and the locomotive continues moving. As steam starts to come from the drain cocks, the cocks are shut and the locomotive then operates normally. When the locomotive is not in steam the drain cocks are left open to allow any water to drain away as the loco cools down. When the loco is being stored for a period the cocks are shut, after allowing the engine to cool, to prevent rust forming in the cylinders.

Check Valve, Washout Plug, Boiler Blowdown Valve



Shown are three other components used on a loco. The Check Valve or non-return valve is used on the water feeds to the boiler and in the oil feed from the lubricator to the cylinders. The Check Valve will need the ball replacing periodically, as the build up of scale will cause it to leak. The Washout Plug is used when flushing out the boiler, about every two years. The Blowdown Valve is used to blow out the water from the boiler after the fire has been dropped and ensures that the boiler fittings do not corrode when the loco is not being used.

Preparation of the Locomotive for Operation

1. **Mechanical Checks.**

a) Locomotive

With the locomotive on the track and with the drain cocks open check that the locomotive moves freely along the track when pushed by hand. After any water comes out of the cocks the loco should move freely with no tight spots. Check that the motion is secure with no obvious slack bolts or loose parts.

b) Carriages

Upend the carriages and check that the wheels move freely on all bogies. Operate the brake lever and check that they operate on all wheels. Try to turn each wheel set by hand to check that the brakes are working. Check the state of the couplings that will be used to couple the carriage to the loco and to each other.

2. **Oiling the Locomotive**

a) Motion work

Oil all the moving parts with the oil gun, paying particular attention to the motion work and axle boxes of the locomotive. Do not “drown” the loco parts in oil or the oil will get onto the track and cause the wheels to slip.

b) Cylinder Lubricator

Fill the lubricator to about $\frac{1}{4}$ inch from the top with Steam Oil, not the oil used to lubricate the loco. Make sure the top is replaced so that dirt cannot get into the tank or the lubricator will stop working.

3. Filling the Boiler

a) Hand pump

With the water tank filled with water, ensure that the Blowdown Valve is shut and then use the Hand Pump to fill the boiler until the Water Gauge Glass shows that the boiler is about half full

b) Pressure feed

Sometimes pressure feed can be used to quickly fill the boiler. The Blowdown Valve is left open and a tube is connected to the drainpipe. The Regulator or Blower Valve needs to be opened to release the trapped air. The pressure feed is then slowly opened and water will be forced into the boiler. Do not open the feed too much or the pipe will blow off the valve. When filling is complete shut the water feed and then the Blowdown Valve and remove the pipe. Shut the Blower or Regulator.

4. Checking the Fire grate

a) Clean

Before loading anything into the firebox it is important to check that all the old coal from the last operation has been removed. This should have been done when the loco was last used (see later "Cleaning the Locomotive"). It is particularly important to check that there is no clinker blocking the fire bars or the fire will not burn properly and the grate could be damaged.

b) Grate Seating

Check that the grate is correctly seated in the firebox. It is sometimes possible to put the fire grate in but resting on the ash pan with no air gap underneath.

5. Fire Starting Fuel

a) Wood

If wood is going to be used to start the fire it should be soaked in paraffin overnight to ensure that it is fully soaked for the next day. The only problem with using wood is that the oil from the wood and paraffin coats the boiler tubes with soot, which is not burnt off during operation. This can effect the steaming capacity of the boiler. This can be cleaned, by using a tube brush after each days steaming.

b) Charcoal

If charcoal is used this should be soaked in methylated spirit about an hour before it is required. This should be done in a tin with a tight fitting lid to prevent the spirit evaporating away. This method provides a clean start and does not coat the boiler tubes.

Raising Steam on the Locomotive

1. Fire box

a) Loading the Start Fuel

With the boiler filled with water to the correct level and all the other checks done, the firebox can now be loaded with the start fuel. It should be well loaded, as it will burn away quite quickly once the fire is lit.

2. Steam Raising Blower

a) Operation

As there is no steam in the boiler when the fire is first lit, we have to use a fan fitted to the chimney in order to draw the heat from the fire through the boiler tubes to make steam. Also, the fire needs to have air put into it in order to make it burn. With the start fuel lit the draw fan is turned on and the fire door is shut.

3. Adding Coal to the Fire

The Start Fuel should be checked after 2 to 3 minutes to check that it is burning properly and some wood or charcoal added if required. After a few minutes a nice hot bed will have formed in the firebox and some coal (anthracite) can now be added to the fire. Do not feed too much coal at a time; about 2 shovels worth is all that is required. You should now notice the Pressure Gauge starting to show that pressure is rising in the boiler. When the pressure indicates about 25 psi the draw fan can be removed and the Blower opened on the boiler. Keep an eye on the fire but do not load coal above the bottom of the firebox door or the boiler tubes will clog up. As the pressure continues to rise, slowly close the Blower to reduce the fire draw.

4. Check the Safety Valve's

Once the Pressure Gauge indication reaches the red line, the Safety Valve's should start to blow off. Keep the fire drawing on the Blower and check that the pressure does not rise more than 10% above the red line on the Pressure Gauge. If it does the locomotive should not be used until the Blower is modified to reduce the amount of "draw" it gives to the fire. This is usually achieved by fitting a smaller jet in the smokebox. It could also indicate a problem with the Safety Valve's

5. Checking the Water Feeds

a) Hand Pump

With the blower on minimum to keep the fire drawing, use the Hand Pump to feed water into the boiler. This is now pumping against the pressure of the boiler. The water level in the Water Gauge glass should rise slowly and the boiler pressure will start to drop. Leave the level at about 1/3rd way up the glass.

b) Injector

Open the Water Feed to the Injector and check that water flows from the Overflow Pipe. Open the Steam Valve feed to the Injector and check that the water from the Overflow Pipe reduces and that a singing noise is heard which indicates that the Injector is working. Keep an eye on the Water Gauge glass, as the water feed is quite rapid. When the level is about 2/3rds the way up the glass, shut the Steam Feed and then the Water Feed. The locomotive is now ready to use.

Driving the Locomotive

1. Initial Checks on the Locomotive

Before loading the train with passengers the locomotive should be used to drive up and down the track to warm the cylinders, check out the locomotive and set the stop markers. While doing these checks keep the Blower slightly on and keep a check on the fire between each task.

a) Setting Stop Markers

On an “up and down” track, the driver cannot see the end of the track when driving in reverse. Two stop markers are placed near the track to indicate the slowing down and stop points. Although track end stops must be provided, the train should never hit the end stops; it should stop about 12 inches from them.

b) Warming the Cylinders

Open the cylinder drain cocks, put the locomotive into forward or reverse gear, depending on the required direction of travel, and then slowly open the Regulator. The locomotive will start to move and steam and water will start to come from the drains on the cylinders. Drive to the end of the track and then close the Regulator to stop (Take Care). Shut the drain cocks, move the reverser to the opposite side and then slowly open the regulator to drive back to the start point. The exhaust beat from the chimney should now be more pronounced as all the steam from the cylinders is now going up the chimney. Close the regulator to stop and move the reverser into mid-point. The reverser should **always** be in mid-point when the locomotive is stopped to take on passengers or do work on the locomotive.

c) Locomotive Water Feed Pump

To check the Water Feed Pump, the Bypass Valve should be shut and the locomotive driven up and down the track as for warming the cylinders but leaving the drain cocks shut. The water level in the Water Gauge glass should rise which indicates that water is being pumped into the boiler. Slightly open the Bypass Valve and run the loco in this position. The bypass should be adjusted to keep the water level at mid point in the Water Gauge.

d) Checking Carriage Braking

When driving the locomotive, it does not have any brakes and we rely on the carriage brakes to stop the train. As the locomotive approaches the stopping point, the Regulator is shut and the brakes on the carriage are applied to bring the train to rest. Check that this happens **before carrying any passengers.**

2. Carrying Passengers

With all the above checks now completed, the train is now ready to be used for carrying passengers. Keep an eye on the fire and water in the boiler to keep the loco ready for use.

a) Loading the Train

The driver should be left to look after the train and a second person should be responsible for loading the passengers onto the carriages. He should inform all the passengers that they must keep their feet on the side boards at all time and not lean out to one side. There must be a space left at the back for the guard who should watch the passengers when the train is in motion to ensure that they do not lean out to the side or drag their feet along the ground. This could de-rail the train or cause an accident to the passengers. With the train loaded the guard should then inform the driver that the train is ready to go.

Ideally the guard should have a whistle so that he can tell the driver to stop if there is a problem.

b) Unloading the Train

Once the train comes to a stop after the ride; it is the responsibility of the guard to unload the train. The driver should concentrate on the locomotive to check the water level, fire and add water to the water tank if required.

3. Periodic Checks

a) Fire box

As the train is used the fire burns away and ash is produced which drops underneath the grate and accumulates. This should be raked away or the air to the fire will be reduced and the fire will not burn properly. The inside of the firebox should be raked to settle the coals and to check that “clinker” is not forming. Ideally the aim is to keep about a 1 inch of depth to the fire, any more than this and the ash is drawn into the boiler tubes, which causes them to block.

b) Lubrication

About every hour, go round the loco with the oilcan and lubricate the motion work and axle boxes. Just a small amount is required, which keeps the loco nicely lubricated and minimises wear.

Check the Lubricator Tank and add Steam Oil as required to keep the tank topped up. Once you are used to the rate of oil usage this check can be reduced accordingly. If the oil looks milky there is a problem with the non-return valves, this must be fixed or the cylinders will not be lubricated and the locomotive wear excessively.

Maintenance of the Locomotive after use

1. Dropping the Fire

With the use of the locomotive finished, the fire must be removed from the firebox before any water is removed from the boiler. Pull out the pin securing the grate and the fire and grate should drop out onto the floor. It sometimes may need a push with the rake to make this occur due to the build up of ash.

2. Blowing down the Boiler

With the fire removed from the boiler firebox the boiler can now be blown down to empty the boiler. This needs to be done as a concentration of impurities builds up which is not removed with the steam. Leaving water in the boiler can affect any fittings sitting in the water and can lead to premature failure. Open the Blowdown Valve with pressure in the boiler and leave it open when all the water has gone until the locomotive cools down. This will stop any water siphoning back from the water tanks into the boiler. The water tanks can be emptied at this time if a drain valve is fitted.

3. Clean the Locomotive

The locomotive now needs cleaning ready for the next use. Open the smokebox door and clean out the ash, which has been drawn through the tubes from the fire. Make sure the ash does not get into the lubricator; ideally a tray should be used to rake the ash into. Use a tube brush to clean the boiler tubes. Just one push through is all that is required this ensures that the tubes are clear for the next use. If the brush cannot be pushed through use a smaller rod to carefully break up the ash and then put the brush through. Do not use excessive force or the tube could be damaged and perhaps the boiler. The rod can sometimes be put in from the firebox end depending on its

position.

If the build up of ash in the smokebox is excessive, try running with a lower fire level and keep the Blower on the minimum to keep the fire burning.

Clean the sealing face on the smokebox door and its mating surface on the smokebox. This ensures there is no leakage of air into the smokebox during operations, which would reduce the steaming capability of the locomotive.

Shut the firedoor and use a paraffin soaked rag to clean all the oily deposits from the paintwork of the locomotive. Clean the motion work with a rag and then wipe over the motion with an oily rag to keep rust from occurring.

Refit the grate to the firebox, as the loco will have cooled by this time.

The last job is now to put a few drops of oil into the top of the Safety Valves, this stops any rust and scale forming and prevents sticking or leakage when next used.

Open all valves on the back of the boiler slightly, again this will prevent them sticking when next used, adding a small drop of oil to each spindle.

4. Lay up for future use.

If the locomotive is now going to be stored for a period before it is used it should be cleaned as per the above procedures. If the locomotive has a steel smokebox door this should be thoroughly cleaned to remove all deposits and some grease then be applied to prevent rust forming. Leave the door open to prevent condensation forming. Unless the locomotive is going to be stored in a warm dry atmosphere it is now advisable to go over all of the locomotive with an oily rag to prevent rust forming and then to cover the locomotive over with a cloth which will keep any damp from getting at the locomotive.