Supporting Model Engineering since 1970

Federation of Model Engineering Societies

Steam Engine Driver's Manual

Issue date : 16th August, 2024

info@fmes.org.uk 01327 342167 www.fmes.org.uk

A private company, limited by guarantee, registered in England and Wales, No. 9002737
Registered Office: 18 Wakefield Way, Nether Heyford, Northants, England, NN7 3LU

Table of contents

1. Introduction

A steam engine is a device that uses steam under pressure to produce physical motion. In principle, it consists of a vessel containing water that is heated by some form of combustion system. The heating produces steam which in turn results in pressure in the vessel if the outlets are restricted. The pressurised steam is, in turn, applied to a mechanical system to produce motion.

The engine may be a locomotive running on rails or a road tractor or traction engine. In general, the term 'locomotive' is used throughout to denote either a rail or road vehicle unless the context requires clarification.

Typically, a steam locomotive has a boiler heated by a fire, some form of regulation of the steam output and a system of cylinders, pistons and levers. The pressure of the steam pushes a piston along the cylinder and a crank converts the linear motion to rotation.

This simple system requires a number of ancillary components to make it function usefully and safely. The fire requires means for providing fresh oxygen (air) for the combustion process and an exhaust system to dispose of the gaseous combustion products. It also requires means of replenishing the fuel as it is used up and, generally, a means of disposing of the non-combustible by-products (ash and clinker).

The boiler requires a means of replenishing the water as it is used up and a means of regulating the flow of steam from the boiler to the motion. For safety, it also requires means to prevent the internal pressure from becoming excessive.

The motion work that converts the movement of the piston to rotation also requires a system of valves to control the admission of steam alternately to opposite ends of the cylinder in order to provide a reciprocating action. That motion work is usually in the open air and requires constant or at least regular periodic lubrication.

All of these systems need to be managed properly for safe and effective operation. The boiler in particular presents a very significant safety hazard. It usually contains a large amount of stored energy, both as heat and as pressure. Most of this Manual is concerned with the safe operation of the boiler.

2. Scope

The purpose of this Manual is to provide a reference for both new and experienced drivers. It may also provide a basis for the assessment of both new and experienced drivers by a club's Compliance Manager or Safety Officer.

The Manual is limited to the requirements and procedures for the safe operation of steam-powered vehicles, including railway locomotives and road tractors (traction engines). However, many of the topics, for example boiler management, are also relevant to the operation of stationary steam engines.

It does not cover those aspects of driving locomotives on railways or tractors on roads that are not related to the management of the steam vehicle - for example, observation of signals or signage, control of passengers, etc.; in other words those aspects of operation that would generally apply to any sort of engine irrespective of its means of propulsion. Some aspects are noted where especially relevant.

3. Safety and certification

The boiler represents a serious potential safety hazard. The energy contained in pressurised steam is much higher than in the equivalent amount of compressed air. The contents are also at a temperature that can cause severe scalding injuries.

Most of the energy is stored as thermal energy in the pressurised hot water. If the pressure is suddenly released the steam in the boiler simply expands outwards, more or less just as air would do. However, the majority of the boiler contents, which had been in the form of water, is rapidly converted to a mixture of steam and hot water occupying a volume much greater than the original water - about 200 times more, and at a temperature of 100C. A boiler with 5 litres of contents at 6 bar would expand to just about 1 m^3 of scalding hot mixture, travelling at high speed and perhaps carrying with it boiler fragments or fittings.

To manage the safety of boiler operation, statutory regulations include stringent design, manufacture and operating conditions [PER [1], PSSR [2]]. These are extensive and complicated laws that apply to all practical boilers. There are exceptions to cover very low pressure systems (< 0.2 bar, 3 psi), but these are not applicable even to small models.

To provide a practicable framework for 'hobby' and amateur operation, a number of organisations together set up a group to interpret the statutory requirements as they applied to model engineering. That group is now the Model Engineering Liaison Group (MELG [3]). It includes representatives from the 10¼" Gauge Railway Society, the 7¼" Gauge Society, the Association of 16mm Narrow Gauge Modellers, the Gauge 1 Model Railway Association, the Midland Federation of Model Engineers, the Model Power Boat Association, the Northern Association of Model Engineers and the Federation of Model Engineering Societies.

The MELG issues a Boiler Test Code (BTC [4]) to cover the examination and testing of steam boilers. Every boiler must have a Written Scheme of Examination to record the boiler material, capacity, fittings, maximum working pressure and test schedule.

Every boiler must pass an initial hydraulic test at 2 times the stated maximum working pressure. At regular intervals during its lifetime the entire system (all fittings and pipework) must pass a repeat hydraulic test at 1½ times working pressure. Annually, every engine must pass a steam accumulation test to verify that the safety valves are able to release all of the steam generated by the boiler under test conditions and that the systems for maintaining the water level within the boiler are working reliably.

Under the BTC, Societies and clubs represented on the MELG are authorised to nominate their own Inspectors and to issue the certificates.

Except for the purposes of the above testing, no boiler should be operated without having valid certificates for the four test elements – namely Written Scheme, Initial Hydraulic Test, Repeat Hydraulic Test and Steam Test. It is also highly advisable that appropriate insurance cover is in place.

4. General description

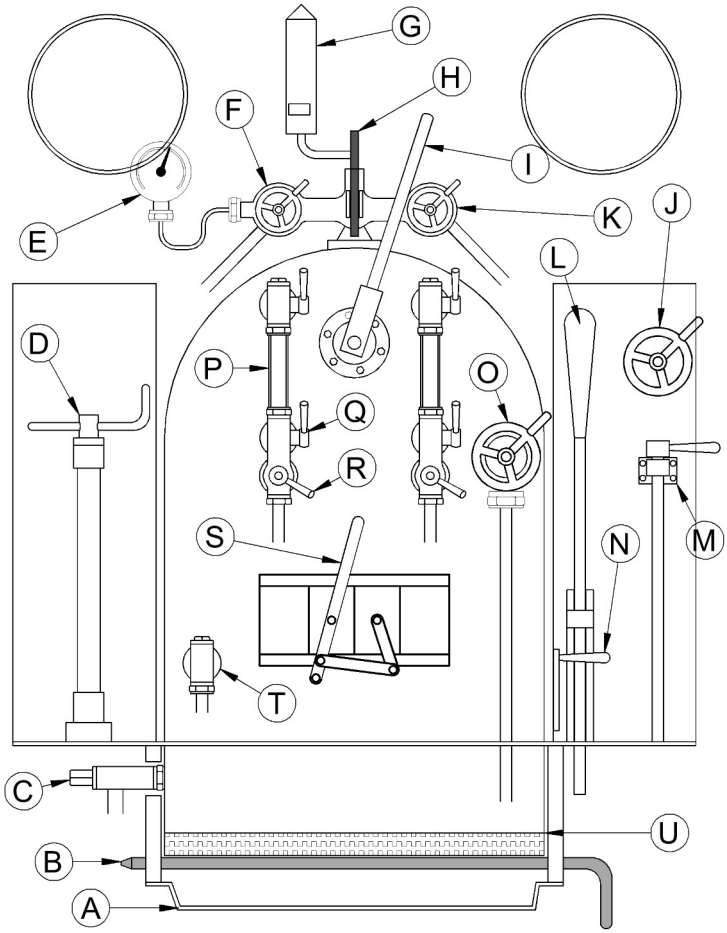

Figure 1, General layout of controls

4.1 Engine controls and layout

Fig. 1 shows a schematic of a typical model steam locomotive from the position of the driver. Of course, all engines will have different controls, arranged differently, but the general principles will be the same. Engines may have more or fewer of some components, but at least one of those shown, or an equivalent, will be present in a coal-fired engine.

Key to Fig. 1

A Ash pan, to collect the unburned residue from the fire.
B Grate pin, for removal (dropping) of the grate (Section 4.4).
C Blowdown valve, for draining boiler (Section 6.1).
D Handbrake.
E Pressure gauge, showing the pressure in the boiler.
F Injector steam valve (Section 4.3).
G Whistle (Section 8).
H Whistle valve.
I Regulator (Section 4.6).
J Axle pump bypass shutoff valve (Section 4.3).
K Blower steam valve (Section 4.4).
L Reversing lever (sometimes a rotary leadscrew arrangement) (Section 4.6).
M Injector water valve (Section 7).
N Cylinder drain cock operating lever (Section 6.1).
O Vacuum brake valve, not always fitted, especially on smaller models (Section 4.9).
P Water level gauge (gauge glass or sight glass) (Section 4.2).
Q Water level gauge shutoff cocks (two for each gauge) (Section 6.1).
R Gauge glass blowdown cock (Section 6.1).
S Firebox door operating lever (door sometimes hinged instead) (Section 6.2).
T Boiler feed clack valve (often more than one).
U Grate, to support the fire and allow air to flow through to the fire (Section 4.5).

Items E, F, G, H and K are often mounted on an assembly called the ‘Turret’, as shown.

4.2 Water levels

The water level in the boiler must be maintained between two critical levels. The top of the firebox (called the ‘crown’) has a seriously hot fire on one side and, usually, cooling water on the other side. It must never be left uncovered because to do so would result in severe overheating of the crown material, leading to possible softening, distortion and ultimate failure.

The water level gauge(s) are arranged so that the lowest visible water level is still safely above the level of the crown.

Some boilers have special, heat-sensitive (fusible) plugs in the crown so that overheating causes the boiler contents being thrown on to the fire. It is not recommended to rely on these in models because because the plugs may fail to act just when needed as a result of scale build-up and lack of maintenance. Alternatively, frequent removal for inspection can cause the fixing threads in the crown to become dangerously worn. Fusible plugs are commonly thought to cause more problems than they prevent. In addition, in small boilers they can cause violent ejection of the firebox contents into the cab area through the firehole door.

If the water level is allowed to rise too high then the steam space above the water is restricted and the engine will rapidly run out of steam when the regulator is opened. Also, (hot) liquid water may be expelled from the safety valves. A water level that is too high may

also result in liquid water being ‘carried over’ to the cylinders. That may cause a ‘hydraulic lock’ and severe damage to, and possible destruction, of the cylinders.

4.3 Water feeds

The steam used by the engine during operation must be replaced by fresh water to maintain the level in the boiler. Steam is used constantly, even when the engine is not actually moving, through leakage, condensation and in maintaining operating conditions by injectors and the vacuum brake system.

Model steam engines usually have three different methods for replenishing the water in the boiler. All have to work against the boiler pressure, except when starting (firing) up. That pressure may be as high as 14 bar (206 psi) and the quantity required can be significant. Even for a smallish model, it can easily exceed what can be pumped manually.

The main method for most steam engines is a steam-operated ‘injector’. Injectors use live steam directly from the boiler to force water back into the boiler - at the same pressure. That apparently contradictory behaviour is a consequence of simple thermodynamics. An injector needs to be cool to work, so it is sometimes necessary to pour cold water over it if it has become overheated. The injector water supply also needs to be reasonably cool, so it is usually taken from a tank on the tender or driving car, and not from an engine-mounted tank.

The second most common method is some form of mechanical pump, usually driven by an eccentric from an axle or fitted to a reciprocating piston rod crosshead. The mechanical pump will put water in the boiler when the bypass valve is closed. Otherwise, the constant flow from the pump just gets returned to the tank. A common alternative to a mechanical pump is some form of steam-operated pump, consisting of a double-acting steam cylinder attached to a mechanical water pump, usually arranged axially with self-acting valves.

A third common method is a hand pump, usually fitted but only used for starting up, when stationary and the mechanical pump cannot be used, or in an emergency if nothing else works.

Occasionally, an electrically-operated water feed pump might be used, most commonly for initial filling of the boiler.

Not all systems are fitted to all boilers but the Boiler Test Code requires that at least two of them are fitted and working.

4.4 Fire management

The fuel burning system consists of a ‘firebox’ in which the fuel is actually burnt, a system of small tubes carrying the products of combustion through the water space in the boiler and a ‘smokebox’ at the exhaust end. The tubes increase the surface area exposed on one side to the flue gas and on the other the water in the boiler to enhance the heat transfer.

The fire itself is supported by the ‘grate’, which is an arrangement of bars with airspaces between to allow a free flow of air for combustion. The grate is often removable, usually by withdrawing the grate pin.

The firebox is a very confined space in which to raise a good fire and burn a significant amount of fuel. It will not self-ventilate and always requires some form of forced ventilation. Two methods are almost always used in combination. During more-or-less idle periods a device called a ‘blower’ uses live steam from the boiler in a venturi arrangement in the smokebox. When the engine is running, the spent exhaust steam from the cylinders is directed through another venturi system (the ‘blast pipe’) to draw the hot combustion products through the tubes and up out of the chimney.

The smokebox contains the effective components of the two draughting systems. It is closed by the ‘smokebox door’. To maintain the effectiveness of both the blower and the exhaust venturii, and thus the draught, the smokebox door must provide a good seal against the smokebox face when it closed.

Some engines are fitted with spark arrestors to reduce the quantity of hot cinders and unburned coal being emitted from the chimney and falling on the driver or passengers.

After some running, the fire may start to accumulate ‘clinker’. Clinker is the residue of coal that cannot be burned and obstructs the air supply to the fire It comes from pieces of slate inclusions or is formed as glass from melted sand. The fire-iron or rake can be used to stir the fire to allow unburned ash and clinker to fall through the grate.

4.5 Dropping the fire

Occasions may arise when the fire, or at least its heating capability, has to be removed quickly. This may be necessary, for example, when the boiler water level becomes dangerously low. It is then necessary to drop or ‘dump’ the fire to avoid overheating of the boiler shell and components. If possible, find a safe place that will not cause damage to the track or danger to other objects or persons.

With engines where it is possible, remove the grate pin and lower or remove the grate and allow the contents of the firebox to spill out. These will be extremely hot and may start a fire on the track, especially if there is any timber nearby - for example, rail sleepers or supports.

Many engines do not have the means for dropping a live fire so one method of rapidly removing the heating effect of the fire is to stuff a rag or other material down the chimney and turn on the blower to full. The steam from the blower has the effect of excluding oxygen from the fire and it will die quite quickly.

4.6 Regulator

The regulator controls how much steam is permitted to leave the boiler and go into the cylinders. It effectively controls the power of the engine. It is used in conjunction with the ‘reversing lever’ to manage the speed of the vehicle for varying load conditions.

4.7 Reversing lever

The reversing lever alters the arrangement of the valve gear to control the direction of travel of the engine.

In most steam engines, the reversing lever can take intermediate positions to decrease the duration of the steam admission. By shutting off the admission part way through the piston travel the steam is allowed to expand, which leads to more effective use of the steam and significantly greater efficiency.

The full extent of valve travel ('full gear') is usually only required for starting off.

4.8 Cylinder lubrication

Steam cylinders require a grade of lubricant called 'steam oil'. This is usually added to the flow of steam when the regulator is open. A mechanical oil pump will supply oil automatically whenever the engine is moving.

With hydrostatic lubricators, the lubricator regulator valve is used to control a (small) flow of steam to the lubricator sight glass via a condenser. The condensed steam will displace oil from the reservoir. The oil will appear as slow drops in the sight glass.

4.9 Brakes

Most steam vehicles are fitted with a hand brake that mechanically applies friction blocks to the wheels or, more rarely axles or brake disks.

Some rail locomotives are fitted with a system to create a vacuum for use by the engine, the attached train or both. The vacuum is created by a steam 'ejector' that uses live steam from the boiler in a venturi system to extract atmospheric air from a reservoir. As a 'fail safe' system, the vacuum is usually used to release the brakes rather than to apply them. The control for such a system is usually arranged to both apply and release the brakes and automatically re-generate the vacuum with one hand lever.

5. Before starting - tools and equipment checklist

Before firing up the engine all of the necessary materials, equipment and tools should be assembled. It is inconvenient, (at least) if the process has to be interrupted in order to collect a missing item.

For a coal-fired engine, the following will be needed …

- Water, wood or firelighters, coal, matches or lighter.
- Steam oil, lubricating oil (preferably in an oilcan).
- Shovel and rake or fire iron.
- External blower (usually electric but sometimes a compressed air ejector).
- Gloves, eye protection.

6. Starting (firing up)

6.1 Preliminary checks (before lighting the fire)

Begin by checking, with the Track Marshall, Station Master or whoever else is in charge of the area that it is safe and permitted to fire up the engine in that area.

Then check the following …

- The gauge glass isolation cocks, if fitted, are open and the gauge glass blowdown valve is closed.
- The grate and ash pan are securely and correctly fitted.
- All flexible hoses are correctly fitted, in particular that there are no leaks that would allow air to enter the injector.
- The hand brake is on, the reversing lever is in mid-gear and the regulator is closed.
- Any couplings are secure. This includes couplings between the engine and tender, any couplings between coaches in an attached train and any service pipes between engine and tender / water tanks.
- The cylinder drain cocks are open.
- Inside the smokebox that tubes are clean, the blower and blast pipe are aligned, the petticoat pipe secure, the jets in the blower are not blocked, any spark arrestor is properly fitted. Then ensure that the smokebox door is securely closed.
- If possible, test the axle/crosshead pump by opening the pump bypass valve, moving the engine backwards and forwards sufficiency to operate the pump and observing the return flow to the tank.

Make sure you know how to drop the fire in an emergency - see Section 4.5.

6.2 Firing the boiler

- Using suitably treated water (if that is needed), fill the boiler to a level about half way up the gauge glass using the hand pump, a hose pipe or other convenient means. Some owners remove components, such as a safety valve, from the boiler to provide a filling point. This is not recommended as the repeated removal and replacement will damage the threads in time. The blowdown valve can be used for the attachment of a hose pipe if it is not fitted with a non-return valve.
  Use the gauge glass to monitor the water level. Do not overfill the boiler. The level in the gauge glass should oscillate if the engine is rocked backwards and forwards or the gauge glass blowdown cock is opened briefly.
  The water level may not be visible in the gauge glass if the water level is so high that it is above the top of the glass. It is common practice to use glass with an embedded coloured stripe or a diagonal striped panel behind the glass for a clearer indication of a full glass.
  Make sure you know the difference between overfull and too low.
- Fill the water tanks, using suitably treated water if that is needed.
- Fill the lubricators with appropriate oil - steam oil for the cylinders and chassis oil for the motion, axles and wheels. Hydrostatic lubricators will need to be drained of condensed water (see Section 9.1).
- Light a fire on the grate using your favourite method. Some use paraffin-soaked rag, wood or charcoal; others use domestic firelighters and wood. One method is to build a small pile of fuel on the grate and then add some lighted material using the shovel.
- As soon as the fire is alight, turn on the external blower. Drivers of larger traction engine often use a tall extension to the chimney to promote the draught.
- When the charcoal or wood fire is well established, begin to add small amounts of coal. Most model steam engines are sensitive to the type of coal used. Most will not run properly with the ‘wrong’ type. The choice is usually between steam coal or

anthracite. The size of the coals should be appropriate to the size of the grate and firehole door. Trial and error is the only practicable way of finding the best combinations.

- Do not 'force' the fire - raising the temperature too quickly may cause undue stress on the boiler material and joints.
- Gradually add coal until the grate is completely covered with burning coal. Airholes in the fire will severely affect the engine's ability to steam well.
- When the boiler pressure has reached about 2 bar (30 psi) on the gauge, the external blower can be removed and the boiler's own steam blower turned on. If that is done too soon then the pressure will start to fall. Experience will tell you the best time for the particular engine.

While the boiler pressure is getting established, some other 'jobs' can be carried out …

- Lubricate all parts of the motion that are not automatically lubricated by a mechanical lubricator. That may include slideways on crosshead guide bars, valve gear sliding blocks and expansion links, connecting rod and coupling rod bearings, eccentrics, axle boxes, pivots for control levers, etc.
- Check for loose nuts, bolts, couplings, etc., and anything else that appears out of order. This should be done initially but going round with the oil can is an opportunity to make sure.
- Keep the fire stoked up and check the water level frequently. Replenish as needed. Keep the water level about half way up the gauge glass.

7. Initial checks (before setting off)

When the boiler pressure is near or up to the normal working value …

- Open the gauge glass blowdown valve briefly. The water level in the glass should recover rapidly to the correct level. If it does not then the isolation cocks might not be open or there is a blockage.
  Do not use the engine if this test fails. If the reason cannot be found and rectified quickly then drop the fire - see Section 4.5
- Injectors can be temperamental. Start by opening the injector water valve. Usually, a small stream of cold water will trickle from the injector overflow. Then, gradually open the injector steam valve. The water flow should increase substantially and then suddenly stop or reduce to a drip as the injector 'picks up'.
  A 'good' injector will function properly with water and steam valves fully open. Sometimes, it is necessary to reduce one or other to get the best delivery to the boiler. Injectors have a limited range of pressure over which they will operate. Some engines will have separate 'low' and 'high' pressure injectors.
- Use the hand pump to try putting some water in the boiler. It is quite evident when the pump is delivering water against the boiler pressure.
- Vacuum system (if fitted) - open and then close the vacuum brake valve. The brake line pressure gauge (if fitted) should recover to its normal level. If the engine is fitted with vacuum brakes or the train vacuum brakes are connected they can be observed to apply and then release.
- Safety valves - allow the steam blower to run at full capacity until the boiler pressure, as indicted on the pressure gauge, is approaching the maximum permitted pressure. The safety valve should open before the maximum is exceeded. If two

safety valves are fitted it is normal for one to operate at a slightly higher pressure then the other. Under full blower and with a good fire, the maximum permitted pressure should not be exceeded by more than 10%. (+10% is permitted by the BTC but many say that should not be allowed and that the pressure should never exceed the maximum stated in the Written Scheme of Examination.)

- Adjust the steam blower to just maintain the boiler pressure without excessive 'blowing off' from the safety valves.
- With the brake still on and the drain cocks still open, move the reversing lever in to gear and open the regulator slightly. A small flow of steam will pass to the cylinders and out through the drain valves without producing any movement of the engine. Continue this for a while to warm up the cylinders.
- Continue to watch the boiler water level and top up if necessary.
- Continue to maintain a good fire - one that covers the grate with burning coals.

8. Running

Make sure you know the track/road safety codes, track rules, track layout, speed limits and signalling system. Some clubs have an acceptance form that you have to sign before being allowed on the track. Also be aware of any emergency procedures, standard practices and especially of any other engines on the road or track.

When the engine is ready to start (all of the above preliminaries have been completed successfully) …

- Obtain permission to proceed from the Track Marshall / Duty Officer / Station Master if there is one, or there may be some form of signal control.
- If the engine has a train attached with a guard, wait for the guard's signal before setting off. The guard is in charge of a railway train.
- Get into the habit of giving a warning signal on the whistle, horn or other warning instrument before actually moving. Some clubs have rules that insist on it.
- Move the reversing lever into full gear and slowly open the regulator. The engine/train should begin to move.
- When under way and all of the liquid water has been expelled from the cylinders, the drain cocks can be closed.
- Check the boiler water level frequently. Use the axle pump or injector to keep the water level in about the middle of the gauge glass. On roads or tracks with substantial gradients it will be necessary to make allowance for changes in gradients. For example, in approaching the crest of a hill the water level needs to be higher to allow for the fall on the descent side.
- Injectors can be sensitive to movement and may work less well when being shaken about. Often, the injector is used when stationary and the axle pump when moving.
- If the water level is not visible in the glass then begin to put water in the boiler immediately by whatever means are available. Try the gauge glass blowdown to check for any water. If the water is still not visible and you cannot get water into the boiler STOP IMMEDIATELY AND DROP THE FIRE - see Section 4.5.
- Add coal to the fire often and little rather than in large amounts infrequently.
- If the pressure rises too much then it's better to use the excess heat in adding cold water, rather than allowing it to blow off through the safety valves, but do not to

overfill the boiler. Steaming can also be moderated by opening the firehole door and/or adding coal.

- Try the brakes (including any fitted to a train and/or driving car) and become familiar with stopping distances. These will depend greatly on the state of the track or road and the attached load. Stopping distances on aluminium rails are much longer than on steel. Stopping distances on wet roads or rails are much longer than on dry. Stopping distances with heavy loads are much longer than with light loads, especially if the load does not have its own brakes.
- For normal stopping, close the regulator in plenty of time before the stopping point then apply the brakes to make a controlled stop at the desired point. Use the driver's truck and/or train brakes as appropriate.
- When stationary, put the reversing lever to mid-gear and open the blower valve enough to maintain the boiler pressure. Open the cylinder drain cocks and apply the handbrake.
- Do not open the firebox door before opening the blower valve. The sudden access to oxygen from the firehole door can cause the fire to 'flash back' into the cab, which on larger models can result in serious burns to the hand opening the door.
- Take the opportunity when stopped to check the fire and water levels and replenish if necessary. Also periodically check levels in the steam oil and chassis oil reservoirs and re-lubricate the motion.
- Prepare for the next run by making sure that the boiler water level, pressure and steaming rate are returned to the necessary conditions.
- If necessary, use the fire-iron or rake to work the fire to allow unburned ash and clinker to fall through the grate. Eventually, the clinker may become so difficult to remove that the engine has to be taken from service.
- Inform the Track Marshall / Duty Officer / Station Master of your intention to stop running.

9. Closing down and putting away

9.1 Copper boilers.

- Copper boilers are usually put away in an empty state as they don't suffer from corrosion (rusting) in the same way as steel.
- Drop the fire in an appropriate place - usually a steaming bay with containers for the ash and (very hot) remnants of the fire.
- While there is some pressure remaining in the boiler, use the blowdown valve to clear the boiler water spaces of any deposits, especially those on the foundation ring. If left, they will become fixed and (very) hard to remove.
- With hydrostatic lubricators, use any remaining pressure to put plenty of oil into the cylinders, then close the sight gauge glass valve. Do not open the control valve too far as it will flood the sight glass, which will then need to be stripped, cleaned and refilled with brine or with 50/50 glycerine/water mix. Then close the lubricator tank steam supply valve and open the drain valve carefully to gently release any pressure. Then open the filler plug, drain the tank of any water and refill with the correct grade of steam oil. Never open the lubricator tank filler or drain if the boiler is in steam without shutting the tank steam supply valve first.

- With mechanical lubricators, give several turns of the ratchet manually to put plenty of oil in the cylinders, especially if the cylinders and/or pistons are steel or cast iron.
- Clean the ash from the smokebox and brush out the boiler tubes.
- Clean everything and spray all bare metalwork with a water dispersant (WD40?).
- All valves should be left open except for the cylinder drain cocks, which should be closed to retain any oil in the cylinders.

9.2 Steel boilers.

With steel boilers, the hot, wet, oxygenated atmosphere remaining inside a boiler after use will promote rapid corrosion. It is difficult, if not impossible, to dry the inside of the boiler adequately. Accordingly, some (most?) owners prefer steel boilers to be put away completely filled with boiled, hot water. The water is effectively de-oxygenated and protects the steel from atmospheric oxygen. To achieve that, the boiler must be fully filled and heated before dropping the fire …

- The boiler should be blown down when still hot and at about normal working pressure.
- After blowing down, use the remaining steam pressure and injector or hand pump to fill the boiler completely. Valves should be left open to allow escape of air and then very lightly closed. (NOTE - As the boiler cools, closed valves will contract, quite possibly damaging seats, and are likely to be very tight or impossible to open until expanded again on reheating. This is also true for screw-type regulators.)
- Raise the temperature / pressure to boiling point without creating more than a token pressure in the boiler - otherwise the safety valves or blower might emit hot water / steam mixture.
- When the water in the boiler is sufficiently heated, shut of the blower and drop the fire (as for copper above).
- Then proceed as for copper boilers. When the boiler has cooled the valves should be firmly closed, and any loss of fluid be made up by filling with de-oxygenated water either by hand pump or directly into the highest point on the boiler

9.3 Other parts.

Drain all water tanks and leave all water tank valves slightly open.

9.4 Long-term (over winter) storage.

Boilers should be stored in a frost-free environment. It is not practical to remove all traces of water from the whole system.

Some owners prefer dry storage for extended periods, with a low heat source, small heater element or light bulb (filament not LED!) in the firebox

The end of the storage period is a good time to consider de-scaling the boiler and other parts of the system. An appropriate de-scaling solution should be used according to the manufacturer’s instructions. De-scaling helps to remove accumulated limescale inside the boiler. Inadequate de-scaling will ultimately result in the boiler having to be replaced.

Injectors also suffer from limescale build-up. They should be dismantled and the components placed into suitable de-scaling solution. As they are usually made of brass or bronze, they can be de-scaled using a mild acid solution, for example citric acid. The parts of an injector are very delicate and must be handled carefully.

At the end of the storage period it is common to find that some valves/clacks have stuck, usually with dried limescale. Some dismantling and cleaning will often be necessary. Sometimes a light tap will free ball valves.

10. General advice

- Always open the steam blower valve before opening the firebox door when stationary. Otherwise, the lack of draught may cause a large flame to come out of the firehole.
- Drive at a speed that is appropriate for the conditions, considering the state of the track, passenger comfort and safety and the potential need for emergency stops.
- It's not always necessary to use the brakes to slow down. Closing the regulator will provide a controlled degree of braking, as will putting the reversing lever into mid gear.
- Get into the habit of putting the reversing lever into mid gear and the hand brake on whenever you stop. This will prevent any unexpected movement if the regulator should get moved unintentionally.

11. Don't Panic! (Emergencies)

11.1 Priming

Occasionally, the water in the boiler can change from a smooth fluid with controlled steam generation to a disorganised mixture of steam and water. The water changes to a 'froth' or 'foam'. There are several known reasons - inadequate flushing out of de-scaling fluid is the most common. Other reasons are related to water quality - for example the presence of vegetable matter or other contaminants if the water is collected rainwater or it contains too much water treatment. New boilers are particularly prone to priming until all residues from fluxes used in the jointing have been expelled. The priming will result in much of the boiler contents being expelled rapidly through the regulator, cylinders and exhaust. The water level in the boiler will fall very rapidly.

Priming will usually happen when the engine is under load, which is with a hot fire and the regulator open.

- Immediately shut the regulator.
- Using as many of the water feed mechanism as are still working to get cool water into the boiler. Injectors may not work if the boiler is priming badly.
- If the water level in the gauge glass does not recover quickly drop the fire - see Section 4.5.
- Get the engine, and train if attached, to a safe stopping place.
- The priming will have washed most of the steam oil from the cylinders, so it is not advisable to continue running until the engine has been properly attended to. It may be necessary to refill the boiler with fresh water and start the 'firing up' process again.

11.2 Sticking regulator

Regulators have been known to fail to close, either at all (perhaps if some linkage has failed) or partially. Put the reversing lever to mid gear and apply the brakes. If necessary, move the reversing lever slightly to the reverse position. Steam pressure will still be applied to the valve gear but it should not get to the cylinders. Also, opening cylinder drain cocks will help to vent unwanted steam pressure.

11.3 Total failure of water feed systems

If all of the water feed systems fail, perhaps because of lack of water in the tanks, then …

- If the boiler still has water showing in the gauge glass and the distance to a safe stopping place is not too great then proceed slowly using as little steam as possible and stop at the safe place. If the problem cannot be resolved quickly then drop the fire.
- If the water level is not visible in the gauge glass then stop immediately and drop the fire - see Section 4.5.

11.4 Failure of lubrication

The loss of lubrication, either in the cylinders or on the motion, is not usually something needing urgent attention. Drive the engine to a safe stopping place.

11.5 Derangement of the motion

Failure of some parts of the motion, especially of a coupling rod, can cause an immediate seizure of the engine. In the extreme case of a locomotive coupling rod becoming detached at one end and digging into the trackwork, the result is usually a derailment, at least.

There is little that can be done in that case, but adequate pre-inspection of bearings, crank pins and retainers can help to prevent it.

12. References

1 The Pressure Equipment (Safety) Regulations 2016. UK Statutory Instruments 2016, No. 1105.

2 The Pressure Systems Safety Regulations 2000, UK Statutory Instruments 2000 No. 128.

3 Model Engineering Liaison Group – web site reference needed.

4 Boiler Test Code, 1st May 2018 – Volumes 1, 2 and 3, available to clubs and societies via the Federation web site at https://fmes.org.uk/

Robert Walker,
Safety Officer,
Federation of Model Engineering Societies,

22 August 2024