

# STATION ROAD STEAM

Locomotive builders • Workshop services

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## 7 ¼ INCH GAUGE 0-4-0 “STAFFORD”



## OPERATING INSTRUCTIONS & BOILER PAPERWORK

## **1. Introduction**

”Stafford” is a large, robustly-engineered locomotive which, whilst not intended as a scale model, is based on typical industrial engine practice of the early twentieth century. Our aim has been to produce a powerful engine which is reliable and easy to maintain.

The engine weighs 430 pounds and requires careful handling to avoid injury – mechanical handling, using a hydraulic lifting bench and ramps etc is highly recommended, the engine cannot easily be handled or lifted manually.

### **Terms used in this manual**

Throughout this manual, right hand means the right hand side of the engine from the driver's point of view – so, for example, the reversing lever is on the right hand side, the brake handle on the left.

## **2. The new engine**

Your new engine will be delivered assembled, tested and ready to run. It will have been run on compressed air in our workshop to check valve setting then steamed prior to despatch to check operation of injectors and the safety valve.

## **3. Controls**

The engine controls are as follows:

Regulator on right of fountain, opens counter-clockwise, closes clockwise

Injector steam valves to left and right of fountain for left and right injectors respectively

Injector water valves operated by valves mounted on the footplate – turn to the 6 or 12 o'clock position for on, 3 or 9 o'clock position for off

Blower steam valve on left hand side of fountain

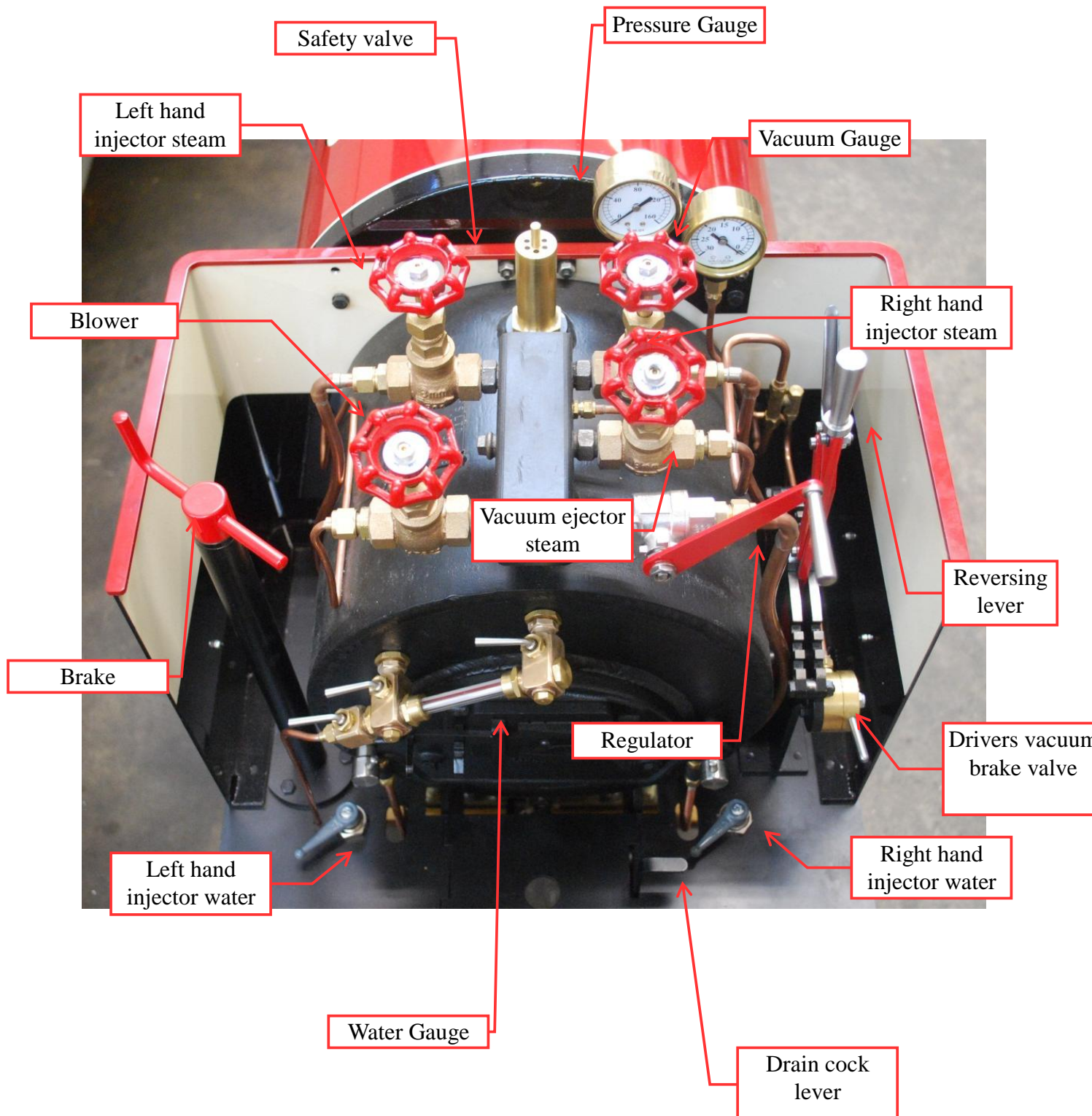
Water gauge on backhead, three-cock pattern with blowdown valve at bottom

Mechanical brake acting on rear wheels on left hand side of cab – turn clockwise to apply brake

Reversing lever on right hand side of footplate – push full forward for starting off forward, back to start off backwards. Move two notches towards centre for normal running.

Drain cock lever on right hand side of removable centre footplate – pull to open

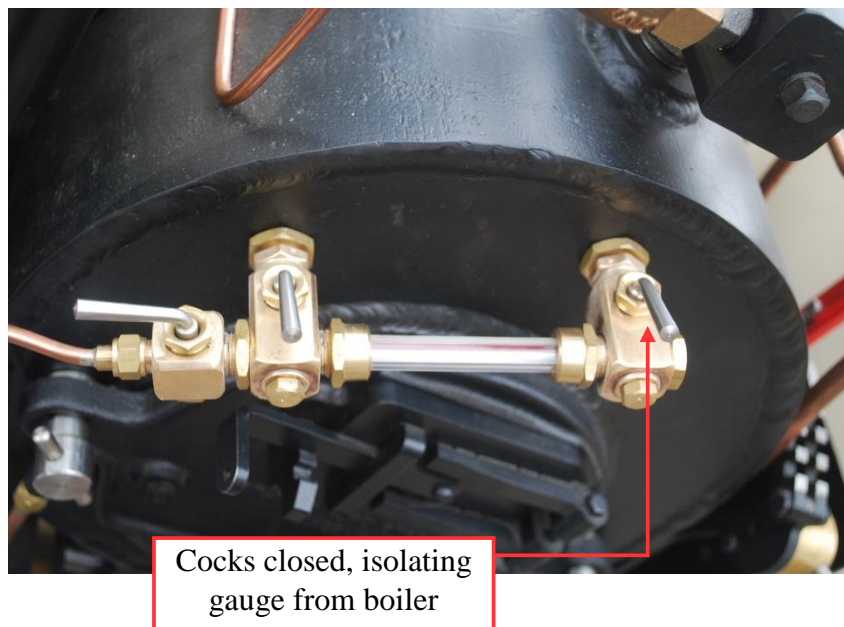
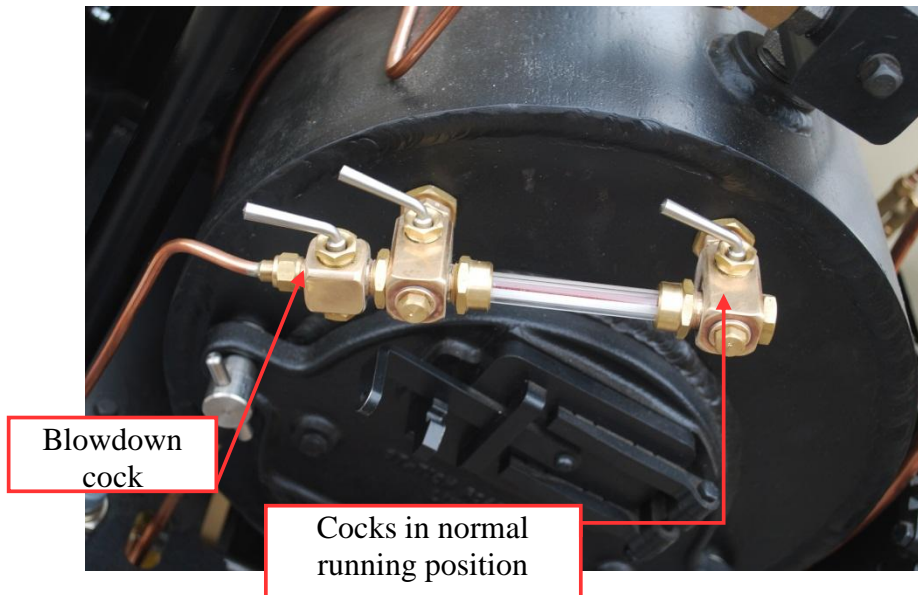
Blowdown valve underneath boiler, accessibly by removing centre footplate section.



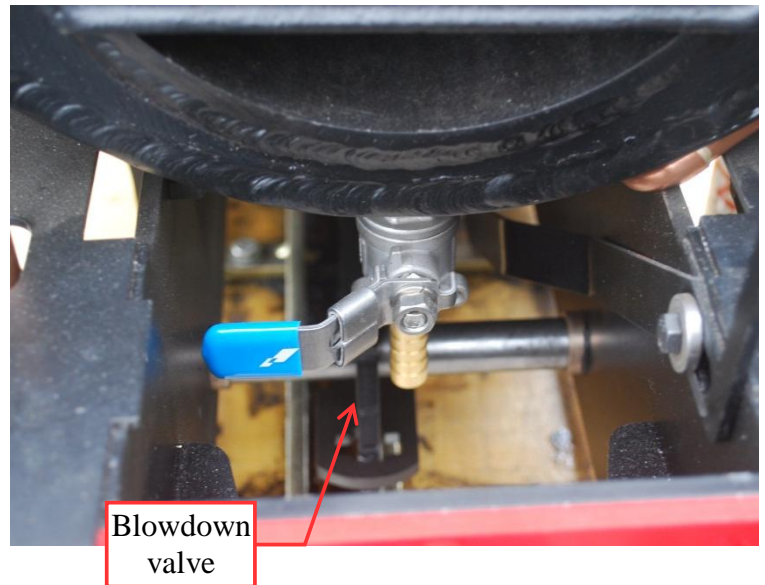
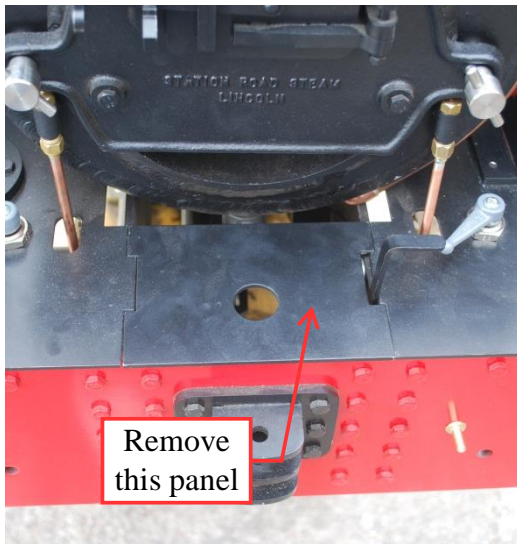


### Preparing the engine to steam

When first preparing the engine to run, stand it on a level piece of track, make sure the brake is on, the reverser is in mid-gear, the regulator and all steam valves are closed and the drain cocks are open.



To fill the boiler from empty, connect a pipe to the bottom blowdown valve which is located underneath the firebox, accessed by removing the centre footplate section.



The blowdown valve is fitted with a standard hose-fitting – snap the hose on and turn on the water, then open the valve to fill the boiler, making sure the injector steam valves are open to allow air to escape.

Fill the saddle tank – it takes around four gallons from empty – and, if using water treatment, add to the tank.

Check that all valves are free to operate, then close before lighting the fire.

We recommend charcoal for starting the fire, this should be soaked in paraffin, preferably some hours before use and well-drained. Cover the grate in charcoal.

The boiler requires artificial draft to steam from cold – this can either be provided by an electric steam-raising blower or by a compressed air dart placed in the chimney. The draft should be strong enough to draw the fire up brightly, not so strong as to heat the boiler too quickly – a good rule of thumb is that the engine should take about 45 minutes to steam from cold. Any longer than this and the blower is possibly too small (or the kindling and/or coal unsuitable), any shorter and the boiler is being unnecessarily stressed (and you won't have time for an oil around and cup of tea while waiting for steam to be raised).

With the external blower on, light the charcoal and shut the firehole door. Within a few seconds a steady roar should be heard – as soon as the charcoal is well alight (within five minutes) coal can be added. Start with four good shovelfulls which will cover the burning charcoal, as it in turn lights, add more to build up a good depth of fire.

As the water starts to boil, the level in the water gauge will start to bob up and down. Check correct operation of the gauge by opening its blowdown cock at the bottom and shutting it again.

The water level should disappear and then return to its original level quickly. If it doesn't, there is a blockage in either the top or bottom fitting – stop and investigate before proceeding further.

Shortly after the water start to boiler, the pressure gauge needle will move off its stop as steam is raised. At 50psi, the artificial blower can be removed and the engine's own blower opened.

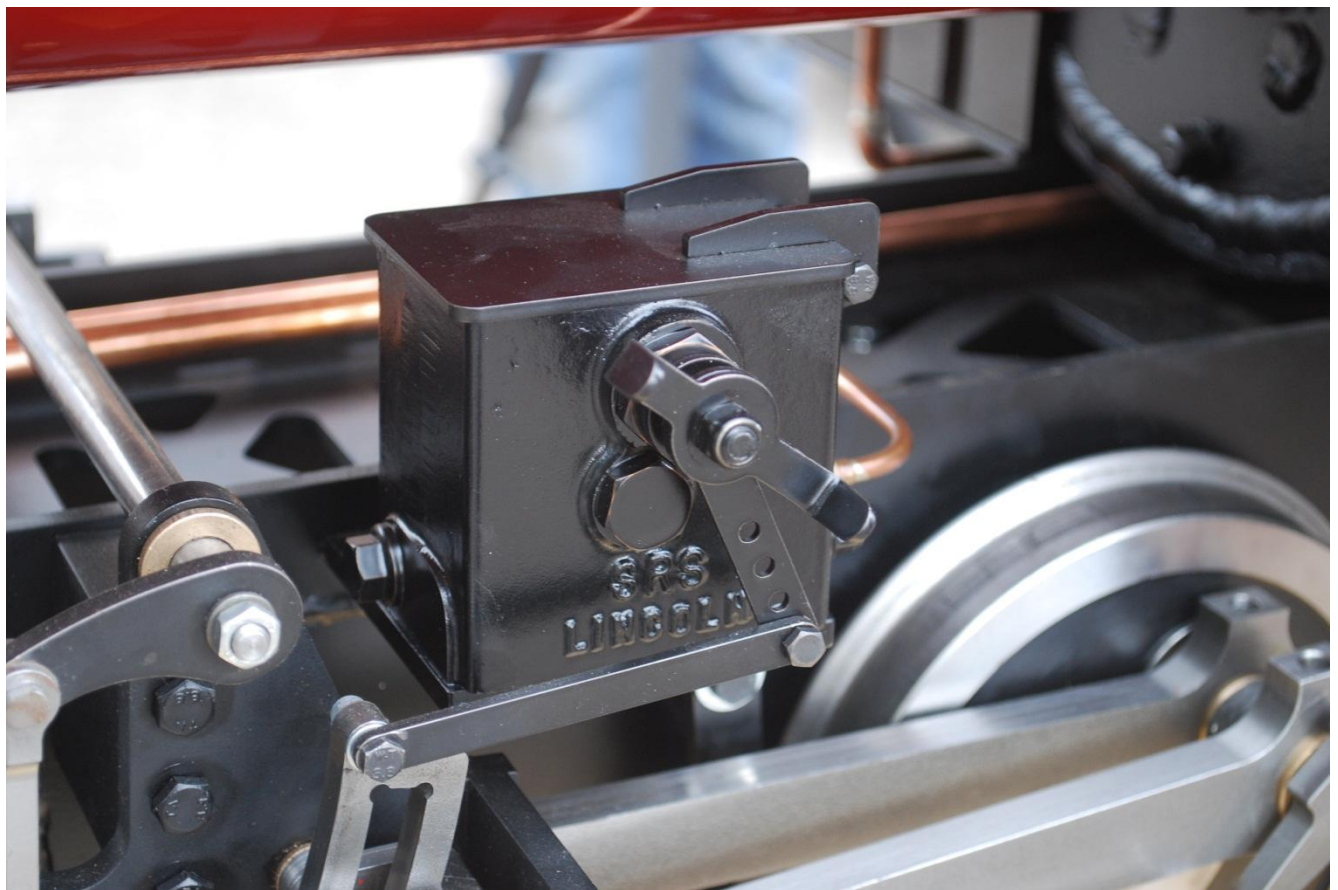
At 80psi, try both injectors to ensure they work efficiently (see section 7.4 on use of injectors).

## **Lubrication**

Waiting for the engine to raise steam is a good time to oil around.

The engine needs two grades of oil – a steam oil to lubricate the cylinders and a bearing oil for everywhere else. We recommend Morris 680T compound steam oil and Morris 220 bearing oil.

The cylinders are lubricated by the mechanical lubricator which is mounted on the nearside of the engine just behind the cylinder block. It comprises a tank with a high pressure pump inside which feeds cylinder oil into the main steam pipe to the cylinders, lubricating the slide valves and cylinder bores. Using the correct grade of oil is important – ordinary bearing oil will not provide adequate lubrication at the temperatures involved.



The valve gear, connecting and coupling rods are all provided with oiling holes, which should each get a squirt of oil at the start of a day's running and at regular intervals throughout the day. The axles run in sealed roller bearings and do not require additional lubrication.

## **Driving**

A steam engine is a deceptively simple-looking machine – anybody can, with a few minutes instruction, fire and drive a locomotive sufficiently well to get around the average club track. However, driving it well, keeping the boiler at working pressure whilst at the same time not wasting steam from the safety valve, anticipating the road conditions ahead and ensuring sufficient fire and water in the boiler to cope – in short, everything that goes to make up good enginemanship – that is an art to be mastered, it is the challenge which makes driving a locomotive interesting.

### **4.1. Starting off**

When first starting off or after the engine has been stood stationary for a while, steam will condense to water in the cylinders on first opening the regulator. Ensure the drain cocks are open to clear the water before moving off, by moving lever forward.

Before attempting to move off, look around to make sure that the track is clear ahead and passengers are all safely in the carriages.

Put the reverser into full forward gear, unscrew the brake and gently open the regulator by moving it to the left. The engine will start to move. Once underway, as soon as the draincocks show steam rather than water they can be closed, as the engine picks up speed the reverser can be moved back two notches for normal running.

### **4.2. Running**

Whilst running at speed, keep an eye on the water level and fire. The water level in the boiler should be kept at a minimum of a quarter of a glass – if it drops lower, stop immediately and inject water. If, for any reason, the water level continues to fall, the entire firebox assembly can be quickly removed by undoing the two M8 retaining knobs on either side of the backhead – it will be extremely hot and a thick pair of gloves will be required.

If the water level is allowed to fall to the bottom of the gauge glass, the firebox is fitted with a fusible plug – this is a bronze plug threaded into the crown of the firebox with a central hole filled with lead. The lead will melt allowing steam to extinguish the fire and relieve pressure.

Note that, as on all engines, opening the regulator violently or too quickly can cause the engine to prime – this is where water from the boiler is carried down the regulator pipe and into the cylinders along with the steam. This is potentially damaging to the cylinders, causing a hydraulic lock – if it happens the engine will slow, the exhaust note changes to a “soggy” sound and the exhaust will go from a clear haze to a white, steamy cloud. Immediately close the regulator and open the drain cocks, it will quickly clear whereupon the drain cocks can be closed and the regulator opened again, more gently this time!

### 4.3. **Stopping**

The engine is heavy and, when hauling a train, possesses considerable momentum – stopping needs to be planned ahead wherever possible.

When stopping at a station to allow passengers on and off the train:

As the engine comes to a stand: open the drain cocks, put the reverser into mid-gear, crack the blower valve open a little and apply the brake. Check to see that the fire is bright, take the opportunity to add coal if necessary. An engine will often lift the safety valves when coming to a stand after a run – the fire is burning brightly from the blast, the boiler is making steam, when the regulator is closed boiler pressure will rise. To counter this, put an injector on whilst standing.

### 4.4. **Injectors**

The engine is fitted with a pair of injectors to feed water to the boiler, each rated at 2 2/3 pints per minute – either is sufficient to supply water for all normal running conditions on its own, with the second acting as a backup. They will pick up from the working pressure of 120psi down to around 70psi – it is important to keep the water at a quarter of a glass or more.

To operate the injector, open the water valve and check that water runs from the injector overflow. Turn the steam valve on slowly at first until injector overflow shows a rapid stream of water, then open the valve quickly and fully. The overflow will, at working pressure, stop and water will feed into the boiler as the injector picks up – if you listen carefully you will hear a distinctive “chirping” as the injector works. To stop injecting water, close the steam valve and shut the water cock.

At lower pressures, start the injector as above, but at a reduced steam pressure the overflow will continue to dribble. Carefully ease the water cock closed until the overflow stops and the injector picks up, as above.

The injectors are reliable devices, if they fail to work check that there is water in the tank and it is getting to the injector (seen at the overflow), the clack valves are working, with the balls free to move on their seats, all union nuts are tight on the injector and, finally, that the injector itself is clear and clean.

To remove it undo the three union nuts connecting it to the pipework and hold it up to the light – you should be able to see right through it. If it is blocked, don't attempt to push a pin or wire into it – this will simply damage the cones – but blow through to dislodge any dirt. If the injector becomes scaled it can be cleaned by dropping in vinegar for a few minutes (this works more quickly if the vinegar is warm). – this will not normally be required if the engine is run using water treatment as recommended.

### **Water treatment**

We use a tannin-based compound which reduces corrosion and the build up of scale in the boiler. It is highly concentrated and should be added until the feed water has the appearance of weak tea. In practical terms, this means about a dozen or so drops of treatment per tank full of water – the colour can be seen either in the gauge glass or injector overflow. Avoid over-dosing, as the engine then has a tendency to prime.



## Disposal

At the end of a day's running the engine can be prepared for putting away – this involves dropping the fire and, optionally, draining the tanks and boiler.



It is a good idea to allow the fire to die down before attempting to drop it. Using a thick pair of gloves, remove the two M8 threaded knobs either side of the firebox and withdraw the entire firebox assembly and tip the remains of the fire into an ashpan or metal bucket.

Brushing the tubes should be done after each day's running, it's easiest to sweep from the firebox end with the firebox assembly removed – push the brush right through then pull back to remove soot in the tubes.



Refit the firebox to the boiler and replace the knobs immediately to prevent cold air causing leaks at the tube ends. Don't move the engine under its own remaining steam with the firebox removed –it will draw cold air in through the hot flue tubes and again contribute to leaks.

The engine can be left with water in the boiler and tank if it is to be used again shortly, alternatively they can be drained.

If draining the boiler, ensure that the pressure is down to 5 psi or less. Remove the centre footplate section and carefully open the blowdown valve underneath. Be aware that several gallons of boiling water will be ejected with some force, ensure that the area is clear of bystanders and that ballast or grit isn't thrown up by the water jet.

## **Boiler maintenance, testing and safety**

The boiler is of all-welded steel construction with expanded steel tubes. It is of the marine, stayless type, as used in full-sized industrial practice by Bagnall.

The boiler is hydraulic tested to twice working pressure during construction and is supplied with the manufacturer's certificate for this test. The document is important and should be kept safely – it is proof of the original test, subsequent hydraulic tests are then conducted at one and a half times working pressure. A copy is bound into the back of this manual.

Due to oil contamination from the manufacturing process of the boiler plate and subsequent operations during the construction of the boiler itself, a new boiler will tend to prime for the first few steamings. During this initial period, pay particular attention to light, careful use of the regulator to avoid water being carried over into the cylinders.

The break-in period can be speeded up by mixing up a strong solution of washing soda and filling the boiler to three quarters of a glass, then putting the engine into light steam for two hours.

**Don't attempt to open the regulator during this time** (otherwise oil will be scoured not just from the boiler, where it isn't wanted, but also from the valve chests and cylinders, where it most definitely is)

Use just enough blower to keep the fire alight and the water boiling – the pressure should be kept below 80psi and the injector used to top up the slight loss of water due to operation of the blower. At the end of the two hours, allow the fire to die down and pressure to reduce to 5psi, then remove the fire completely before blowing down to empty.

Testing:

The boiler will require annual inspection and test by a competent authority throughout its life. There are two main schemes for achieving this – either by having the engine tested at your local model engineering club, or by using the services of a commercial boiler inspector.

The club test regime requires hydraulic testing of a steel boiler four years from date of manufacture, then every two years thereafter – for this test the boiler is pumped up to one and a half times working pressure for ten minutes – with a steam test annually, when operation of the safety valve will be checked, along with two independent means of feeding water into the boiler.

A commercial inspector will make an examination of the boiler annually – the so-called “cold inspection” when plugs can be removed allowing examination of the inside of the boiler, followed by a steam test much like the club test. A hydraulic test, however, is carried out less frequently, typically at seven or ten year intervals

## **Trouble-shooting**

The boiler is a free steamer, if the engine doesn't maintain working pressure easily there is something wrong.

Check that the smokebox door is tightly shut, firebox door is shut, fire is adequately made up – the engine runs best with a thick fire – with a decent coal. We use and recommend the coal supplied by Signal Fuels of Ripley, although any other good quality steam coal can be used. It is important that it burns completely to an ash that can drop through the grate, best size is around 20-30mm lumps.

Put the reverser is full forward or reverse for moving off, but when running it should be moved back two notches. This will use the steam very much more economically, requiring less coal and water.

Run the engine at close to the working pressure. The higher the pressure, the less coal and water are required to run any steam engine – running around at 60 or 70 pounds on the clock will make maintaining steam hard work.

### Technical information

In correspondence please quote the works number of your engine, which is stamped to the rear of the chassis on the left hand side.





Length 45 inches  
Width 19 inches  
Height 32 inches  
Weight 429 pounds dry, approx 500 pounds in running order

Steel driving wheels 6 ½ inch diameter tread  
Sealed bearing axle boxes

Bore 2 ¼ inch  
Stroke 3 inch  
Cast iron cylinders, each piston fitted with two Clupet rings  
Mechanical lubricator

Welded steel boiler with expanded steel tubes  
Working pressure 120psi  
Mild pop type safety valve, bronze body, ½ BSP thread  
1/4 BSP fusible plug  
Throatplate fitted with ¼ BSP washout plug  
Front tubeplate fitted with two off ¾ BSP washout plugs

Boiler feed two 2 2/3 pint injectors

Water tank TIG-welded stainless steel, capacity 4 imperial gallons

Rear coupling:  
Steel bar coupling supplied as standard with 10mm pin  
Mounting points two off M6 threaded holes, 57mm centres  
Height from rail head 95 mm

Lubrication  
Steam lubricator – Morris 680T steam oil or equivalent  
All other – Morris 220 mineral oil or equivalent

**Useful numbers**

Blackgates Engineering	Steam fittings, coal, oil, electric steam-raising blowers, Reilang oil cans, flue brushes	0113 285 3652 <a href="http://www.blackgates.co.uk">www.blackgates.co.uk</a>
Morris Lubricants	Steam oil, available by mail order	01743 232200 <a href="http://www.morris-lubricants.co.uk">www.morris-lubricants.co.uk</a>
Signal Fuels	Steam coal	01773 550126

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## "STAFFORD" BOILER USER MANUAL

## 1. **Introduction**

The boiler for your new locomotive has been manufactured from high quality material - used and maintained correctly it will give many years of safe service.

The boiler is designed to produce steam at high pressure - as such there are inherent risks, both from burns and scalds. Read this manual carefully before use, if you have any questions regarding its use please contact the manufacturers.

## 2. **Fittings**

Ready to run locomotives are supplied with all fittings already installed on the boiler. Kit-build engines will require them to be installed - full instructions for this are included in the kit assembly manual.

Fittings are in bronze, rated for the appropriate temperature and pressure encountered in normal operation.

### a. **Safety valve**

This is factory set for 120psi operation. Regulations state that the safety valve must not permit the boiler pressure to rise more than 10% over working pressure - the valve fitted is capable of doing this with a large safety margin. Be aware that, on a new boiler, the safety valve will tend to lift water when the safety valve opens - after several steamings this will reduce.

### b. **Water gauge**

A three cock water gauge is fitted, allowing the glass to be isolated from the boiler in the case of breakage. The blow down valve at the bottom should be operated at regular intervals to ensure that the gauge is showing a true reading - when opened, the water will be blown out of the glass, when closed it should return to its original level quickly - if not, then there is some restriction in the fittings which must be investigated.

**Under no circumstances operate the boiler when the water level is below the level of the glass - serious damage may be caused.**

### c. **Fusible plug**

A bronze fusible plug is fitted in the crown of the firebox, such that a lead core will melt under low water conditions, giving audible and visible warning - steam and/or water will appear below the grate. If this happens, draw the fire immediately to prevent damage.



### 3. Testing

During manufacture we hydraulic test the boilers at twice working pressure for 30 minutes - this test is witnessed by our insurers, their certificate is bound into the operating handbook and should be kept with the engine. The test pressure and working pressure, along with serial number for the boiler is stamped into the "CE" mark plate, fixed to the boiler at the top of the outer wrapper, alongside the safety valve bush.

Locomotives supplied as ready to run will also have had a steam test, to check operation of the safety valve and injectors.

### 4. Operation

Firing and driving your new locomotive is covered in the operator's handbook, however those aspects specific to the boiler are repeated here:

- a. Filling with water: the blowdown valve is fitted with a 1/2 inch hose adaptor, allowing the boiler to be filled from a standard hosepipe - open the injector steam valves when filling, to allow air to escape as the boiler fills.
- b. Kindling: we use charcoal soaked in a small amount of paraffin or heating oil. Drain off any excess - ideally wet the charcoal an hour or two before use to allow the paraffin to be absorbed - otherwise burning paraffin tends to drip through the grate and out along the bottom of the firebox, which is both messy and dangerous.
- c. The boiler requires an artificial draught to raise steam. The best method is an 18 inch length of copper pipe, bent into a "J" shape and dropped down the chimney, the loop of the "J" pointing back up. Attach to an airline providing 20psi, which will cause sufficient draught to draw the fire.

An alternative is to use a electric fan-type blower, as provided by the model engineering supplies.

Whether using the compressed air or electric fan method, a 7 1/4 inch gauge "Stafford" should take 45 minutes to reach working pressure of 120psi from all cold. Longer than this and your fan may be too small, quicker than this and you are unnecessarily stressing the boiler, as one end heats up much more quickly than the other.

- d. Use the engine blower before opening the fire hole door if coal has recently been added - in these circumstances volatile gases can build up and "blow back" if the door is opened.
- e. Water treatment: we recommend a tannin-based water treatment, which will reduce the amount of scale and corrosion and extend the life of the boiler. A bottle is supplied with all new engines - it is added in small concentrations, typically so that the water in the gauge glass has the colour of weak tea. Any more than this and the boiler will suffer priming.

Water treatment works by throwing impurities in the water out as an insoluble sediment - for this reason, the boiler must be blown down regularly. To do this, when the boiler is at low pressure - no more than 10psi - open the blow down valve beneath the firebox briefly, to allow some water out. This is best done at the end of the day with the fire removed.

- f. After a day's steaming, the firebox and tubes need to be cleaned. To avoid stressing the boiler by rapidly cooling it, we tend to clean out an engine the morning after, however at times this is impractical. If the engine is to be disposed shortly after use, remove the grate (this will be extremely hot, you will need a thick pair of gloves and poker) and dump what remains of the fire in a safe place (a tin tray is useful) before replacing it. Open the smokebox door and brush the tubes before closing the door - again to keep heat in the boiler.

## 5. Safe operation

Like many things in engineering, using a boiler safely is largely a matter of common sense. However, if we can offer some words of advice:

- a. Keep your engine clean - there is nothing like getting close to a piece of machinery when cleaning it to show up things that are loose/broken/missing, small maintenance jobs are much easier and cheaper than major rebuilds...
- b. Have the boiler tested regularly - it will need a steam test annually and hydraulic test at four year intervals if tested under club regulations. If the boiler has been run low on water and melted its fusible plug, seek expert advice and have the boiler thoroughly inspected before further use.
- c. Fittings often leak slightly when cold, as they warm up they will be perfectly steam tight. However, there is no excuse for fittings leaking steam at operating temperature/pressure, this is a hazard which must be rectified as soon as possible, once the boiler is cold. **On no account attempt to tighten leaking fittings with the boiler in steam.**

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## "STAFFORD" BOILER RISK ASSESSMENT

## **1. Hazards anticipated**

- a. Injury handling the boiler, due to weight
- b. Burns from fire or hot metal parts

Use gloves when operating the boiler. The backhead in particular gets particularly hot, don't attempt to remove it without a pair of thick, heatproof gloves.

- c. Scalds from hot water or steam

Ensure fittings are steam-tight - if not, inspect at the earliest opportunity when the boiler is cold. Do not attempt to tighten fittings with the engine in steam.

- d. Emission of steam from safety valve: the valve is of the pop type and will vent steam rapidly if the boiler pressure rises above working pressure. The steam is directed upwards, keep clear of the safety valve chimney at all times.
- e. Emission of sparks and cinders

## **2. Persons at risk**

- a. Driver and bystanders, particularly younger people who may be tempted to touch hot parts of the boiler
- b. Person handling the boiler when removed from the locomotive, or whilst being fitted as part of a kit-build.

## **3. Control measures**

- a. Use best practice when handling or lifting boiler, it needs at least two people to handle safely - consider mechanical handling aids, lifting blocks etc
- b. Take care when the engine is in steam, wear gloves to protect hands
- c. Driver of the locomotive should consider eye protection to avoid getting hot cinders in eyes
- d. Warn bystanders of potential risks, in particular if they touch exposed parts especially back-head, outer firebox and smokebox.

## **4. Residual risk**

- a. Accidental contact with hot parts



- b. Unsupervised bystanders coming into contact with hot parts

## **5. Risk assessment**

- a. Risk assessment is low when used in accordance with correct operating procedures laid out in manual

## **6. Recommendations/Further actions**

- a. Avoid touching exposed hot parts

## **7. References**

- a. Boiler user manual