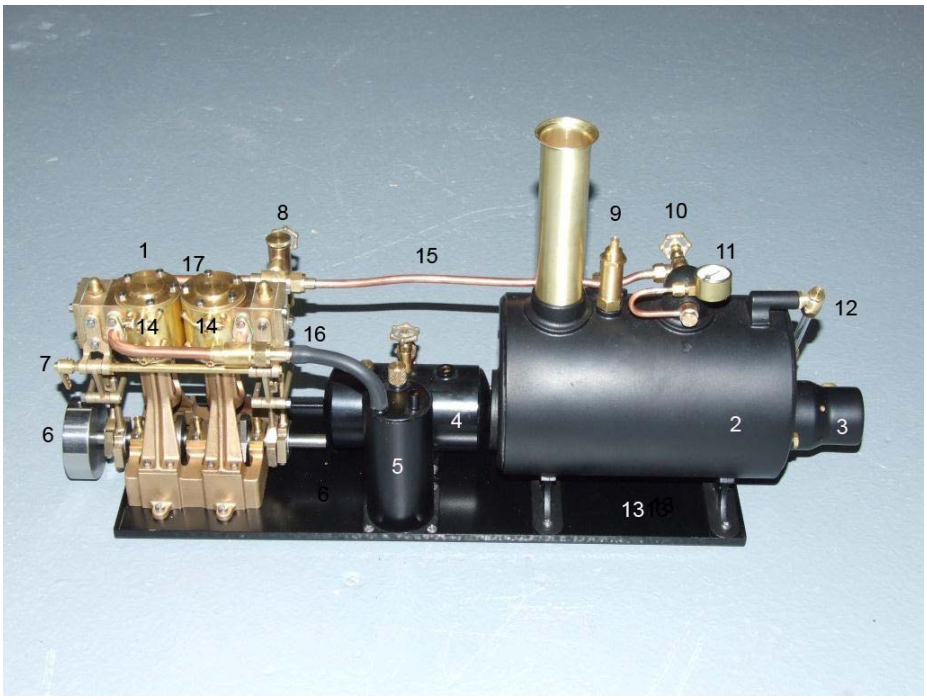
OPERATION OF "*Miniature Steam*" SLIDE VALVE STEAM ENGINES

This note is intended to address the interests of new users of ***"Miniature Steam"*** steam engines. Since an engine alone has no purpose but to look beautiful, its operation must be seen in the context of the components that are required for it to perform its primary function of powering something – in this case we are highlighting the operation of an engine in an integrated steam plant using ***"Miniature Steam"*** 4" horizontal boiler and Mildura twin cylinder slide valve engine as follows. The descriptions apply generally to any engine/boiler combination.



STEAM PLANT COMPONENTS:

The engine (1) must be mounted on a firm base – a brass mounting plate (13) in the illustration. Beware of mounting the engine on an uneven base that may lead to distortion of the base when screwed down. This could cause binding of the crankshaft in its bearings leading to poor engine performance, if not actual seizing of the engine.

The engine is connected to the boiler (2) by a steam line (15) with a steam cock (10) at the boiler end and the displacement lubricator (8) at the engine end. The cock on the displacement lubricator is used to adjust the rate of flow of oil into the steam stream, delivered to the engine through the inlet manifold (17). As delivered to the engine, the use of the steam flow is regulated by the setting of the slide valve eccentric timing in the case of non-reversing engines and by the setting of the Stephenson's linkage with reversing engines. Engine speed control with non-reversing engines is controlled by the steam cock and with reversing engines by the combined action of steam cock and the setting of the Stephenson's reversing linkage (7). Spent steam is discharged from the cylinders through the exhaust manifold (16) into the oil separator (5) which in turn exhausts clean steam to atmosphere. The boiler burner (3) is powered from a refillable gas tank (4) which can be easily remover for safe refilling in open air. Steam pressure is indicated on a pressure gauge (11) and the safety valve (9) can be adjusted to release steam if the pressure exceeds the working pressure of the boiler. Water level in the boiler is indicated in the water level display gauge (12). An important element in the power train is a flywheel (6). Shown is a low profile stainless steel version purpose designed for marine installations. A variant of this with conventionally constructed spokes is also available but takes up much more vertical room in the normal steam powered model boat.

STEAM GENERATION – BOILER OPERATION:

Compressed Air:
It is possible to operate a steam engine with compressed air; in fact this is often done for short runs when testing engines. If planning to use compressed air for a longer period a special lubricator should be installed; it is strongly recommended that compressed air **should not be used** at all for other than short duration testing.
Burners:

Fundamental to operating a boiler is a heating device. Some of the smaller boilers use spirit or tablet heat sources but the boilers used by serious modelers are generally heated by various gas types delivered through ceramic elements. Generally there are two types of ceramic burner elements – those that are machined out of general purpose heating tile blocks and those that are constructed as cast ceramic elements tailored for the burner/boiler combination. ***"Miniature Steam"*** boilers exclusively use the custom designed cast ceramic elements because of the superior performance that may be obtained. To obtain maximum performance, these burners need to be tuned to the actual installation. Appendix 1 provides instructions for calibrating these burners.

Boiler Water Level:

It is important to ensure the correct water levels are maintained in the boiler by proper use of the water level sight glass. This is fitted to the boiler so that it shows water levels in a safe range. If the water level is not showing, the boiler has too much or too little water. Too little water can result in boiler damage. Too much water will impede the generation of steam and result in poor boiler performance and excessive water in the steam line. Boiler feed pumps, both steam driven and manually operated, can be used to maintain water levels during a run, but a well-designed system will have balanced gas supply vs. boiler water capacity that will give session running times of 20 to 30 minutes. ***"Miniature Steam"*** 2" boilers are refilled by removing the safety valve. The 3" and 4" boilers have separate filler nuts for water refills. With 3" vertical boilers this is located under the cowl and with the 3" & 4" horizontal boilers it is adjacent to the pressure release valve. Clean "soft" water should be used to minimise accumulation of scale in the boiler. The syringe supplied is used to add water through the filler port or to remove excess water the same way.

The Pressure Release Valve (Safety Valve)

WARNING - DO NOT TRY TO GET IMPROVED OUTPUT FROM THE BOILER BY ADJUSTING THE PRESSURE (SAFETY) VALVE ABOVE THE RECOMMENDED MAXIMUM WORKING PRESSURE FOR THAT BOILER!

Each boiler is fitted with a pressure release valve that will vent the steam from the boiler if it passes a pressure appropriate to each boiler. This pressure is **NOT** set at the factory on delivery; the customer must make a setting according to local conditions and regulations. During the initial run-up period the 2" boilers require the removal of the safety valve to refill the boiler, allowing an opportunity to adjust the vent pressure setting. The 3" and 4" boilers have separate ports for water refills and require separate action to remove and adjust the pressure valve setting. On each run allow the valve to discharge and note the discharge pressure before drawing off steam. At the end of each run, when the boiler is cool, remove the valve and vary the setting of the adjusting nut, ¼ turn at a time. Repeat the procedure until the valve discharges at the required pressure.

Coping with condensate:

In simple terms steam is water vapour that is produced when water is boiled. It will return to water if its temperature is reduced below the boiling point of water. When delivering steam from a boiler to an engine, the higher the delivery temperature and pressure the more power can be generated by the engine. Thus heat lost by the steam after leaving the boiler and arriving on the top of an engine piston will reduce the potential power of the engine. In the extreme case of steam being delivered to a cold engine the steam will condense to water in the engine cylinder and impede its operation. With slide valve engines the engine will stall if the condensate is not removed by opening the steam drain cocks. It is desirable to keep the drain cocks open until the engine reaches operating temperature.

Steam Oil Separator:

At the other end of the steam journey, to meet environmental requirements, the spent steam, with the lubricating oil drawn in from the lubricator, has to be passed through a steam condenser/separator, sometimes called an oil trap or steam trap. In this component the lubricating oil in the steam is separated from the cooled steam and the clean steam proceeds to the atmosphere minus its oil load. The oil collected is extracted from the condenser, and discarded, at the end of each run using the syringe supplied. Do not be tempted to re-use the collected oil. Always use the syringe to take out the oil in the condenser while it is still warm. It can be difficult to draw out if it is allowed to cool before extraction.

Boiler Lagging:

Historically most working boilers were clad with insulating materials to minimise heat loss from the boiler shell. ***"Miniature Steam"*** 3" & 4" model boilers are supplied with a wood lagging kit for self-assembly to help minimize heat loss. There are a number of factors to consider before deciding to install lagging on your boiler (See Appendix 2 for installation guidelines) . An additional benefit of the wood lagging is to improve the cosmetic appearance of the boiler and to minimise risk of contact skin burns during operation. If wood lagging is not desired for a particular situation, e.g. cold ambient temperatures requiring warming of the gas tank for efficient combustion, the highly efficient ***"Miniature Steam"*** cast ceramic burners provide sufficient heating capacity to cope with radiant heat losses from an unlagged boiler in reasonable ambient temperatures.

Why/how to lag the steam supply pipes:
In commercial situations the distance between a boiler and the engine generally was sufficient to require lagging of the steam supply line to minimise heat loss. This was a commercial imperative that does not necessarily apply to modeling situations when the original design is scaled down. It may be advisable where the steam line is relatively long, or when there are many stop/start actions that will leave live steam in the pipe long enough to lose significant heat when maneuvering the boat. Otherwise it only needs to be used to authenticate the model. This can easily be accomplished by closely wrapping natural fibrous (e.g. cotton) string around the steam line and painting with a suitable white paint to simulate the full size practice.

ENGINE OPERATION:

Warm-up: (see **Coping with condensate** above)
Slide valve engines are fitted with manually operated steam cocks that should be opened during the warm-up period and closed when clean steam is being emitted.

The role of the lubricator:

It is imperative that the cylinder and other internal moving parts are lubricated to minimise wear on the engine. When powering an engine with steam a special high temperature lubricant called “Steam Oil” should be used for this purpose. This is contained in a “displacement lubricator” that injects the oil into the steam supply line while the engine is operating. It works by condensing small amounts of steam in the lubricator body. After the steam condenses in the lubricator, the oil floats on the top of the water and overflows into the delivery pipe. The oil from the delivery pipe is introduced into the steam pipe, where it is atomised and carried to the valves and cylinders. After each run the displacement lubricator should be drained of water and topped up with oil.
As noted above a displacement lubricator is not appropriate where the engine is powered with compressed air. Compressed air should only be used for short test runs.

General lubrication after each run

Light machine oil is recommended for all mechanical parts outside the steam system. Some engines have oil cups to lubricate specific components but these do not cover all surfaces. For working surfaces that do not have an oil cup, squirt the oil in while turning the engine over by hand

General housekeeping:

It is normal for steam plants to get “messy” during operation. The plant tray has fold up edges to collect water and oil to minimise the “messiness” extending to the rest of the installation. It is good practice to mop out the tray after each run and generally wipe away any splashes on the components.

Long term storage:

Generally an engine’s cast components are made from a marine grade non-corrosive alloy; the crankshaft is made from stainless steel or nodular cast iron and the remainder of the machined components from brass. This combination provides maximum protection from corrosion during service if the engine is run regularly. However if you are planning to not run it for a prolonged period – say 3 months or more, the residual condensate that will remain in the cylinder after a run may cause some tarnishing of the cylinder bore. This could cause accelerated wear of the “O” rings and increase the internal friction of the engine during initial startup. In these circumstances we recommend that you remove the top and bottom cylinder covers, soak up the condensate, directly lubricate the cylinder bore (preferably with benign rubber grease) and replace the cylinder covers before storing the engine. This advice does not apply to the Avon engine where the cylinder is factory assembled and should not be dis mantled

Boiler Size vs. Power Requirements:

There is a direct relationship between the required size of boiler and size of engine. The following table illustrates the options available.

Engine/sv	Boiler >	2"	3"	4"
Avon	Twin cylinder 8 mm bore, 11 mm stroke	Yes		
Tyne	Single cylinder 11 mm bore/stroke	Yes		
Clyde	Twin cylinder 11 mm bore/stroke		Yes	
Mersey	Twin cylinder 11 mm bore/stroke		Yes	
Echuca	Single cylinder 19 mm bore/stroke		Yes	Yes
Pevensey	Single cylinder 19 mm bore/stroke		Yes	Yes
Mildura	Twin cylinder 19 mm bore/stroke			Yes
Gem	Twin cylinder 19 mm bore/stroke			Yes
Twin Avon			Yes	
Twin Tyne			Yes	
Twin Clyde				Yes
Twin Mersey				Yes

If a plant is being configured with other third party components the above sizing can be used as a guideline but please note that ***"Miniature Steam"*** boilers have superior steam generating efficiency when compared with most other boilers of similar size. Also when sizing a boiler it may be important to anticipate the use of steam driven accessories such as steam driven boiler feed pumps. There should be no problem with using a larger boiler than the above recommendations to cover this situation.

Appendix 1.

THE BURNER/GAS OPERATION:

The burner converts liquid gas into heat by burning a gas and air mixture in the burner assembly to create heat. ***"Miniature Steam"*** burners use individually designed ceramic burner inserts to provide maximum burner efficiency for each boiler. Following is the description of how to calibrate a burner for maximum performance

Calibrating "*Miniature Steam*" Ceramic Burners

Please note that "Miniature Steam" ceramic burners are only to be used with a Butane/Propane gas mix with a maximum of 30% Propane or Butane/ISO Butane/Propane mix. LPG (100% propane) should NOT be used."Miniature Steam" ceramic burners are specifically designed to provide optimum burning characteristics in enclosed spaces such as the centre flue or firebox of a boiler. They differ from other ceramic burners made from heating tiles designed for radiant room heaters.

The gas/air mixture of a ***"Miniature Steam"*** ceramic burner burns outside the ceramic insert (see picture). This results in a more efficient transfer of heat to the boiler's heating surface. The burner also remains relatively cool thus improving the thermal efficiency of the burner and minimizing the chance of back burning.

Please note that when the burner "roars" it is probably operating efficiently. 2" and 3" boilers have a steady sound where the 4" boiler has a "stuttering" sound imposed over the top of the roar. These sounds are normal for ***"Miniature Steam"*** burners.

As the gas supply may vary by location and from batch to batch, it is advisable to undertake a calibration process before starting up a boiler for the first time and when changing gas batches.
To achieve the correct burning characteristics of the unit with any gas batch, the jet holder is moved in the air/gas mixing tube to establish a correct air/gas ratio in the fire tube.
We recommend the following procedure

- connect the gas source to the burner gas pipe and insert the jet holder into the mixer gas tube
- remove the burner assembly from the boiler and hold it in one hand by the mixer gas tube. (Note: keep your fingers away from the burner shroud – it may heat uncomfortably during the calibration process!)
- start by sliding the jet holder in the mixer gas tube to leave the air holes 2/3 closed.
- turn on the gas and light the burner. You should see a lazy flame flecked with yellow. If not, adjust the jet holder to achieve this. This position indicates that insufficient air is being added to the gas/air mix.
- slide the jet holder to expose more of the air holes until the flame is blue but is "dancing" on the surface of the burner. This indicates that there is too much air in the gas/air mix.
- move the jet holder back to reduce the air hole exposure until a stable blue flame is evident. This is the optimum setting for the air/gas mixture.
- secure the jet holder in the mixer gas tube in this position with the Allen key supplied by tightening the stainless steel 3 mm grub screw provided.
- turn the gas off and allow the burner to cool a little before reinserting it in the boiler fire tube.

When in place in the burner tube the burner is normally lit by turning on the gas and applying a lighted match to the boiler chimney.

The Gas Supply.

The gas used in the burner is supplied as a compressed liquid that follows the immutable laws of physics. Simplified for this note, these mean that when liquid gas in the master reservoir is transferred to a storage container the storage container will get colder, as will the master reservoir. When the gas is drawn off in gaseous form during use, the storage container will again get colder. These facts require particular attention

"Miniature Steam" steam plants have the refillable gas tank attached to the gas delivery line with a knurled nut fitting and the tank is not physically secured to the mounting tray. This is to enable easy detachment for refilling in open air.
Depending on the ambient temperature at the time and the rate of filling, the tank will cool and may even frost up. If this happens, the tank should be brought back to room temperature by dunking it in warm water before refitting it to the plant.
In normal circumstances the above step should be sufficient to get optimum gas release in starting the operation of the plant but there is still the possibility of chilling from rapid gas expansion during early use. This will reduce the amount of gas available for heating and affect the performance of the plant. ***"Miniature Steam"*** plants locate the gas tank as close as practical to the boiler (preferably unlagged) so that there is progressive warming of the gas tank as operation proceeds. In extreme conditions it may be necessary to divert the steam exhaust line through a coil wrapped around the gas tank, to provide the additional warming to offset the cooling process.

Appendix 2

The lagging items supplied with a ***"Miniature Steam"*** boiler comprise suitable sized strips of wood and brass bands to hold them together for an authentic presentation. If a lagged boiler presentation is desired the following procedure may be helpful.
If the boiler has been in use remove it from the tray and clean the surfaces being lagged with an oil free solvent. This is not required for boilers "fresh out of the box".

1. Lay out the slats on a flat surface to form a mat and check for any size variations.
2. Select one slat and fit it to the part of the boiler with the most fittings. Using a sharp knife shape the cut slat so that the edge fits to the centerline of the fitting/s.
3. Spot glue the fitted slat with thick Cyano Acylate glue and fit it to the boiler shell. Only use sufficient glue to lightly secure the slat. Full securing of the lagging assembly will be accomplished when the boiler bands are fitted.
4. Spot glue the next slat to align with the first, again trimming as necessary.
5. Continue this process until slats are fitted to half the boiler surface.
6. Repeat steps 3 to 6 from the other side of the boiler.
7. Gently sand the lagging to remove the ridges that occur where the slats meet and give the lagging several coats of acrylic varnish to seal the surface.
8. When the varnish is dry, fit the boiler bands to secure the lagging.