The Zimbabwe Bush Pump

"Open top cylinder" model

Peter Morgan
The “open top cylinder” model of the “B” Type Zimbabwe Bush Pump

Introduction

The standard and most commonly used version of the Zimbabwe Bush Pump uses down the hole components comprising 50mm galvanised iron pipe, 16mm mild steel pump rods, a 75mm brass cylinder with matching piston and heavy duty foot valve. The 75mm piston is fitted with two leather piston seals. The two piston seals are the fastest wearing part of any Bush Pump, and in the standard version, their replacement requires the lifting of the rising main (steel pipes) to gain access to the piston and its seals. This is routine practice in Zimbabwe.

However several years ago, models of the Bush Pump were designed with open top cylinders to make routine replacement of the piston seals easier and quicker. This method followed international trends to make routine maintenance (seal replacement) easier. In this design the rising main pipe has a larger diameter than the piston seal, which means the piston can be lifted out through the rising main pipe. Lifting of the heavy pipes is unnecessary. The use of the word “open top” refers to the fact that the cylinder is open at the top, so the piston can be lifted out of it and up the rising main pipe. Whilst about 1000 units of this type were installed in the program, the method never took off nationally. The method is currently being reviewed again.

The OTC (or “user friendly”) version of the Bush Pump uses a combination of a 63.5mm brass cylinder and 65mm galvanised iron pipe as the rising main. This means the piston can be withdrawn through the rising main to the pump head. Two factors on the negative side is that the water output is reduced by X%, and the weight and cost of the rising main increases by a factor of about 1.5X. However the ease of maintenance is increased, which also saves on cost and “down time” (the period when the pump is out of action. This version of the pump is best used on wells and boreholes down to about 30m.

Formerly the 16mm rod connectors were made in the form of a hardened steel “hook and eye” arrangement. There were no threaded joints. However this is not the only way of connecting the rods, and more recently a simpler method has been devised. In this case the original threaded rod connectors are used, but with minor modifications (see later). This revised method is currently on trial.

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The wooden block, which is made of teak, is attached to the pump stand and rotates around a large bolt called a pivot pin. The rods which connect to the piston within the cylinder below, move up and down within a “string” of steel pipes (known as the “rising main”). The uppermost rod passes through a floating washer housing, where a set of 2 moving washers accommodate for the horizontal movements of the rod within the pipe. The uppermost rod is connected to the pump head through a “U bracket.” The U bracket is attached to another pivot pin which passes through a forward hole in the wooden block. The wooden block has 2 sets of holes, a method derived from earlier Bush Pumps. When the first set of holes wears out, the second set can be put into use. The wooden bearing has a very long life.

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PART 1.
Close up photos of the pump head components

The lower part of the pump stand showing the base plate support and apron and the two large 16mm U bolts which secure the pump stand to the 150mm steel borehole casing. The steel casing rises 500mm above the concrete apron. If the borehole is cased with PVC pipe, a length of steel casing fitted with sprags is mounted in concrete around the borehole casing within the apron. On the left the upper part of the pump stand and the U bracket in position.

The modified water discharge unit. The steel pipes of the rising main are connected to this through a heavy duty steel socket. In the open top cylinder model, the heavy duty 50mm socket is replaced by a heavy duty 65mm socket from which the 65mm steel pipes hang. The water discharge unit uses a “floating washer system” to accommodate the movements of the rods as they travel up and down during the pump stroke. A rubber buffer cushions the end of the down stroke. The floating washer system uses an inner and outer floating washer. The inner washer helps reduce foreign objects passing down into the rising main from above. The outer floating washer acts as a base for the rubber buffer to rest on.
The inner floating washer in place. A spacer ring separates the upper and lower plates of the floating washer system. On the right the upper plate has been secured in position and the outer floating washer and rubber buffer fitted.

The pivot pin. This has a diameter of 35mm and is hard wearing and supports the wooden block. It is held in place with a large nut and heavy duty spring washer.

The teak block is the main bearing and lever system on the Bush Pump. It has two sets of working holes. The steel handle is a length of steel water pipe attached to the wooden block with two 12mm U bolts. A central bolt which passes through the handle and the block secures the position of the handle to the block.
“Down the hole” parts

THE FOOT VALVE

The heavy duty foot valve in the open top cylinder version is the version fabricated with a “female” thread for attachment to the 63.5mm brass cylinder. The valve is protected below and above by the addition of stainless steel screens. The reason for this is that in this model, the foot valve is expected to remain operational for long periods of time without attention. It is therefore essential that the valve be protected from items of debris lodging in the poppet valve seat, which might lead to leaks. In this case stainless steel mesh is cut and placed within the housing of the foot valve. Particles able to penetrate this screen are unlikely to affect the performance of the foot valve.

The heavy duty foot valve with “female” thread for attachment to cylinder
The lower half of the foot valve showing rubber seal.

The poppet valve should be clean. It has fins which enable it to rotate whilst working. The poppet valve fits on top of the rubber seat. The poppet valve in place. The lower section of the foot valve screws into the upper section. The poppet valve resting on the hard rubber seat should form a perfect seal. The rubber seat should last for several years before replacement is necessary.
Fitting the stainless steel screens on to the foot valve

A circular piece of stainless steel is cut xmm in diameter and inserted in a bed of quickset epoxy paste (Pratleys white) layer around the upper ledge of the upper component of the foot valve. This bonds the screen to the piston body. On the right a view of the screen from the top.

A rectangular piece of stainless steel screen is cut xmm long and y mm wide and inserted inside the rim of the lower part of the foot valve against the brass windows. This is held in place by threads of stainless steel wire and also in the epoxy paste.

The screen prevents items from the well or borehole jamming in the valve and lengths the period between foot valve servicing. The foot valve is attached to the lower end of the 63.5mm brass cylinder.

The parts of the foot valve should cleaned and be put together tightly. The foot valve is then attached to the lower end of the cylinder. In all cases “plumbers paste” or plumbers tape should be used to ensure a water tight seal.
The 63.5mm open top brass cylinder

This is a single unit made of 63.5mm ID brass tube, 600mm long. The upper end is swaged out to a larger diameter to accept a 65mm thread which will fit a 65mm steel pipe socket. The lower end is also swaged to accept a 50mm thread which will fit the foot valve.

The 600mm long 63.5mm (ID) brass tube which forms the cylinder of the “open top” version of the Bush Pump

The Upper (left) and lower (right) parts of the brass cylinder
THE 63.5mm PISTON

This is a brass unit with a poppet valve and 2 seals made of high quality nitrile rubber. This is a specialised type of hard wearing rubber. Leather seals have been tried in this model, but tend to become soft and may jam at the joints of the steel rising main when extracted. Good seals should last at least 2 years, but seal life depends on amount of use and physical quality of the water.

The complete piston with two seals made of nitrile rubber

Parts of the 63.5mm piston valve
Assembling the piston valve

The parts are cleaned and assembled in order, with the two seals being inserted. The brass piston valve poppet is fitted in place over the brass valve seat.

The upper part (cage) of the piston body is then screwed tightly against the lower part. Wrench (boobijan) spanners should be used to tighten the piston together.
The 16mm pump rod system

The pump rods are made of 16mm mild steel. Earlier open top cylinder models of the pump used a hook and eye system with special case hardened joints. This system can still be used and does away with the need to use rod sockets which are screwed together. However the system described here is easier to make from standardised parts. It is described below.

With the open top cylinder system, the main routine maintenance will involved removing the pump head block, undoing the floating washer and withdrawing the rods and piston. This system has been designed to make disconnecting the 3m lengths of rod easier. Normally each 3m length of rod is joined to the next through a rod socket (50mm length). Upper and lower rods are screwed into the socket so they meet centrally. Each is held by a lock nut. This has been standard practice for many decades in Bush Pump technology. In this revised version, the rod socket is welded to the lower rod and the upper rod has a longer thread which enables one nut to be welded and a mobile lock nut to be used.

Thread lengths on the rods

The rod socket is attached to the upper end of the rod. Two nuts are attached to the lower end of the rod along the longer thread. The rod socket is welded to the rod and also the upper nut to the rod. The lower nut acts as the lock nut. The upper rod is screwed tight into the rod socket, using a spanner on the welded nut and secured by the lock nut.
The hook and eye system

This system was developed in Zimbabwe to make separation of the rods easier on versions of the pump which were fitted with open top cylinders. It is no longer in regular production, but could be re-introduced. The mild steel hooks and eyes were processed so the inner core was malleable (mild steel) surrounded by a case hardened outer shell. This reduced wear and prolonged the life of the joint.

A series of rods fitted with case hardened hook and eyes for ease of separation. On the right the lower ends of 3 versions of brass open top cylinders developed in Zimbabwe – 50mm, 63.5mm and 75mm. The 63.5mm version was the most successful. The 50mm version too little water, the 75mm version used rising mains which were excessively heavy. The 63.5mm version was a compromise with a respectable water output and steel rising mains (65mm NB) which were not excessively heavy.

The hook and eye system developed in Zimbabwe came equipped with tools to hold the joint during separation, and extraction tools if rods were lost. A small number of schools participated in local maintenance supported by enthusiastic teachers. The hook and eye joints were still vulnerable to corrosion, but made rod extraction easy and fast.
Part 2.

Preparing for installation on a well.

Most Bush Pumps are fitted on boreholes. However this section of the manual deals with preparing a well for Bush Pump installation. In this case the short steel casing is caste into the concrete well slab.

The well

Wells are valuable sources of water. They are normally lined with bricks, with a diameter of approximately one metre. The well lining extends above ground level by about two courses of bricks. Then the well slab is laid on top and the head-works (apron and water run-off) built. The short steel casing on which the Bush pump is mounted is supported by a strong concrete anchor which forms part of the well cover. The total depth of concrete supporting the casing is 30cm. The well slab thickness is about 7.5cm. Below slab level the concrete anchor is 22.5cm deep.

Preparing the specialised concrete well slab

In this case the slab diameter was 1.3m being made of a strong mix of one part PC 15 cement, 2 parts river sand and 3 parts stone chips. The slab was reinforced with 3mm wire. The short steel casing which supports the pump is 80cm long and 15cm in diameter and 30cm of this is embedded in concrete. The mould is laid on a sheet of plastic and the casing placed 40cm from one side. The concrete anchor is prepared by digging a hole in the ground around the position of the casing, 21cm deep and 50cm in diameter. In this case the slab mould was made of steel shuttering but can be made of bricks. The total concrete mix for the anchor and slab is 90 litres stone chips, 60 litres clean river sand and 30 litres PC 15 cement.
Photos of slab casting

The slab diameter is 1.3m and thickness 75mm. The slab is cast in concrete (3 parts stone, 2 parts river sand and 1 part PC 15 cement. The 80cm long steel casing is supported in 30cm concrete. This means a concrete anchor must be cast below the slab. This is made by digging a hole 500mm in diameter and 225mm deep in the ground. The edge of the hole is 240mm from the edge of the mould. The short casing has 4 “sprags” welded to it at the lower end.

The hole in lined with thin plastic sheet and filled with the concrete mix. Two circles of 3mm wire are laid within the anchor concrete. The total concrete mix for the anchor and slab is 90 litres stone chips, 60 litres clean river sand and 30 litres PC 15 cement.

The anchor hole is filled with concrete and rammed hard. Then the concrete extends into the well cover. 3mm wire is used as reinforcing. The concrete work is covered with plastic sheet. After the concrete has set, the slab is kept wet for at least 2 weeks before moving. The longer the concrete is kept wet the stronger it will become. It is very important that the concrete develops considerable strength to support the casing and pump. If the concrete is not allowed to cure properly, the casing will come loose.
Moving the slab on to the well and making head-works

After some weeks of curing the slab is moved on to the well

The slab is moved carefully over the well and embedded in a layer of cement mortar.

The head-works is made by mortaring a ring of bricks around the rim of the slab and extending these into a water run-off channel 2.5m long. The head-works is plastered with a slope to allow water to run off the slab into the channel and then into a bed in which bananas have been planted. The plasterwork is left to cure for several days and kept wet once hardened.
Fitting the Bush Pump

The well (or borehole) is measured for depth and the length of the rising main adjusted. The foot valve should be placed 50cm from the bottom of the well. The pump head is inspected and all the pipes, rods, cylinder with piston, and foot valve. The rods are prepared as described earlier in this manual. The 65mm piping is heavy and will require a tripod, block and tackle and suitable tools to install.

Stage 1. Fitting the pump head

The wooden block, water discharge unit and large U bolts are removed from the pump head. The pump head is placed on the steel casing, adjusted to the correct position and then clamped tight with the two large U bolts.

The foot valve is fitted to the cylinder (if it has not been fitted before), and the cylinder fitted to the 65mm steel pipe socket attached to the lowest 65mm galvanised pipe. Plumber’s past is used on the threaded joints to make a watertight seal.
The 65mm steel pipe is lowered through the base plate of the pump head. It is supported from the block and tackle by a pipe lifting device. The pipe is held in place with a pipe clamp. In case the pipe socket is attached to the upper end of the pipe. All threaded joints are put together with plumbers paste. This makes the joints more water tight and also makes separation of the pipes easier at a later stage.

Pipe sockets are used to connect each pipe. The thread of the uppermost pipe is attached to heavy duty socket of the water discharge unit.

The water discharge unit is held on a rope suspended from the block and tackle and lowered on to the pump head. The water discharge unit bolts are done up tight. The rising main is now installed. Next comes the installation of the piston and rods.
Installation of piston and rods

The piston comes attached to a 600mm ( ) length of pipe rod. The lower end is threaded into the piston head and held tight with a lock nut. The upper end of each rod is fitted with a rod socket (rod connector) which is welded in place. The rod socket is held in a rod holding tool during installation. A new rod is then threaded into the socket and held tight by the lock nut. Note the upper and lower rods should meet in the middle of the rod socket. A new rod holding tool has been designed so it also clamps the rod socket in place.

The upper rod is screwed into the rod socket using a spanner on the upper welded nut. This is done up tight. Then the lock nut is screwed up tight. The specialised rod holding tool holds the socket in place whilst the rods are being connected. The tightening is done in two stages. All the rods are lowered and connected in this way.
Cutting the rod at the correct length and threading

The rods are attached together until the piston reaches the bottom of the cylinder. At this stage the rod protrudes beyond the water discharge unit. The rod must now be cut at the right length.

To mark the place on the rod where is should be cut, the parts of the floating water housing (spacer ring, upper plate, floating washer and rubber buffer) are assembled besides the rod and a mark made at the level at the top of the rubber buffer. Using a hacksaw the rod is cut off level at this point.

The rod is now lifted (with wrench spanners) and a 50mm long thread made with a 16mm die (thread cutter). The pipe opening is covered with a rag to stop metal cuttings falling down the rising main.
Once the thread is cut and cleaned, the parts of the floating washer housing are assembled around the rod (spacer ring, lower washer, upper plate, upper washer, rubber buffer) and the U bracket is attached to the upper end of the rod. The U bracket is screwed down tightly and a lock nut added.

The wooden block is now added to the pump frame and the two large 35mm pivot pins added. These have squared heads which meet plates on the pump frame and U bracket. These plates are designed to reduce wear on the pump frame and bracket. Note the plates are attached above the head bolt on the pump frame and below the head bolt on the U bracket.

The large nuts are held tight with a large spring washer and done uptightly with a pump spanner.
Fitting the pump handle

The standard pump handle is 2.5m long and 50mm in diameter. On shallower wells the handle diameter is reduced to 40mm.

The pump handle passes through two U bolts which pass through the wooden head block. These are tightened behind washers with nuts. A central straight bolt is also used to secure the pump handle in the correct position on the block.

The rear rubber buffer (car tyre)

It is important to fit a rubber buffer to reduce the end knock of the handle on the down stroke of the pump. This also limits the stroke, so that the pump rod does not touch any part of the floating washer housing during normal pumping.

The car tyre is dug halfway into the ground so the rear end of the handle comes to rest on the uppermost part of the tyre. The head-works apron is now cleaned and the pump is ready to use.
Routine replacement of piston seal.

The “B” type Bush Pump has been designed so there is limited wear on the head and spare parts should be needed very rarely. The wooden block has a long life and if the head bolts (pivot pins) are kept tight, any wear on the pump frame and U bracket should be minimal. The wear, even on the floating washers is small, but these are easily replaced. The high quality heavy duty foot valve of this unit should also have a long life before the rubber seat requires replacing. This will require lifting of the rising main. Since the poppet valve of the foot valve is protected against items fouling the mechanism (with stainless steel screens, at least 5 years service should be expected before the foot valve needs attention. The 16mm rods are connected together with specially designed lock-nutted connectors in this model.

This leaves the piston seals as the fasting wear part of the pump. This model has been designed so they can be replaced by withdrawing the piston through the rising main pipe (which makes lifting the pipes unnecessary).

The piston seals are made of high quality 63.5mm diameter nitrile rubber (which must be imported from a reliable source). Leather seals, particularly if they are not high quality, can jam in the joints of the rising main when they are extracted.

The following tools are required for a routine extraction of the rods and piston and its seals. These are required to take off the wooden block, to remove the plates of the upper part of the floating washer housing, to disconnect the rods, and to dismantle and reassemble the piston. Spare piston seals are also required.

Tools required

1. Head bolt pump spanner
2. Floating washer housing spanner
3. Special rod holding tool for holding up rods during disconnecting
4. Adjustable spanner for disconnecting rods
5. Two wrench spanners to disconnect and reassemble piston seal

Photos of tools

The spanners required for lifting the rods and piston and the specialised rod holding tool which holds the rod up and grips the rod socket.
Procedure for replacing piston seals

The following steps are taken to removed and replace the two piston seals

1. Remove wooden block and place on one side
2. Undo the three bolts on the floating washer housing
3. Lift the rods up (the upper rod still has the U bracket connected)
4. Hold the first rod socket up with rod holding tool.
5. Unscrew the lock nut and then unscrew the upper rod to disconnect from the lower rod
6. Place removed rod in clean place
7. Remove all the rods in the same way including the rod attached to the piston
8. Dismantle the piston and thoroughly wash down.
9. Replace the seals with new ones
10. Reassemble and tighten the components of the piston
11. Lower the piston and rod down the rising main holding the rod on the rod holder
12. Reconnect the next rod, tightening down first the rod (using a spanner on the welded nut)
13. Then tighten the lock nut
14. Lower the rod to the next joint and repeat for each rod
15. Lower the top rod with U bracket attached
16. Reassemble the floating washer housing
17. Reassemble the wooden block on pump head
18. Test pump

Stages in photos

Removed both pivot pins and wooden block. Remove 3 nuts holding floating washer housing.
Lift up the upper rod with U bracket attached. Secure the rod with the rod holding tool.

Unscrew locknut with adjustable spanner. Unscrew upper rod from socket using adjustable spanner on welded nut.

Remove upper rod and place on clean surface. Using the rod holding tool, lift the next lowest rod and disconnect in the same way. All rods should be placed on clean surface above the ground to ensure that they remain clean.
Remove all the rods in the same way to gain access to the piston.

Clean piston in water and undo the parts with two wrench spanners.

The parts of the piston laid out. Reassemble piston with new seals.
The piston is assembled with new seals.

Lower the rods in the reverse order. Hold them up with the rod holder whilst the upper rod is screwed up tight into the rod connector, then tightening up the lock nut. The whole “string of rods” is lowered back down the rising main.

The floating washer housing nuts are tightened and then the head block is refitted and the pivot pins inserted and tightened. Routine The pump is now ready to use.
Routine maintenance

The “B” type Bush Pump head should required little maintenance if it has been constructed correctly following the specifications. The pump must be fitted with care and also following the correct procedures.

There are few wearing parts on the head. The floating washers will wear in time. It is essential to keep the main pivot pins tight at all times with the spanner which should be available on site. If the pivot pins are allowed to come loose, then wear will start on the pump frame. Grease or Vaseline should be applied from time to time on the pivot pins to ensure smooth action. This requires removing the pivot pins, applying the Vaseline and reinserting the pin and tightening. Vaseline or grease should not be applied on any other part of the pump. The lock nut on the U bracket should also be kept tight. All nuts on the pump head should be kept tight. These include the nuts holding the U brackets which hold the pump in place on the steel casing and also these that secure the handle to the wooden block.

The piston seals are the fastest wearing part of the Bush Pump in normal operation. On the standard pump, these will be made of leather. It is essential to use high quality leather seals to extend the operational life between seal replacements. Using piston seals of low quality means that the piston will need to be raised more often, which increases the costs of maintenance and also puts the pump out of action for longer periods. High quality “nitrile rubber” seals must be used on the open top cylinder version of the Bush Pump.

It is also important that the foot valve be of the recommended heavy duty type and well tested before fitting. In the open top cylinder type arrangement, the foot valve poppet valve should be protected against the ingress of foreign objects by stainless steel screens. This will greatly reduce the number of times the foot valve will require inspection.

The “open top cylinder” (user friendly) model of the Bush Pump