The Zimbabwe Bush Pump

Recent developments using the 50mm open top cylinder version with 63mm PVC rising main and 16mm pump rods

Peter Morgan
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The Zimbabwe Bush Pump

Recent developments – 2016

This manual records more recent developments of the open top cylinder version of the Zimbabwe Bush Pump using a combination of 63mm class 16 PVC pipe as a rising main and a 50mm open top brass cylinder. The use of 16mm mild steel pump rods has been retained. Previous manuals have described open top cylinder models of the Bush Pump which use 63.5mm open top brass cylinders, with both galvanised steel and PVC (75mm) rising mains (see reference list). The first open top cylinder models of the Bush pump, were developed during the late 1980’s as a collaboration between the Blair Research Laboratory and V&W Engineering. Initially these used 50.8mm open top brass cylinders used with reamed 50mm galvanised steel rising mains. The water output was much lower than the standard use of a 75mm closed top cylinder with 50mm galvanised steel rising main. Later, to overcome the resistance to reduced water output, a 63.5mm open top cylinder was developed, first using 65mm galvanised steel rising mains and in more recent trials 75mm thick walled PVC as a rising main. These cylinders were simple brass tubes, swaged and threaded at both ends to match the appropriate rising main and foot valve threading. Trials were undertaken with these early open top cylinder pumps during the 1990’s, but the government retained the use of the standardised combination of a high delivery 75mm brass cylinder fitted with a heavy duty foot valve and 50mm NB GI rising mains. This system has been retained until the present day.

One of the great technical problems facing the current Bush Pump program in Zimbabwe is the difficulty of replacing the two leather seals held on the piston. Replacement of these seals requires the lifting of all the heavy 50mm steel rising mains. This well tried, but cumbersome operation has been standard in Zimbabwe for more than 80 years. The provision of sub-standard leather seals by some manufacturers makes the situation even worse. Much stricter control of leather seal quality is required. In the view of the writer, the down-the-hole components of the Bush Pump need to be modernised to make routine replacement of seals (the most common maintenance requirement) much easier.

In a continuation of research and development, and the realisation that many installed Bush Pumps are currently non-functional in the rural water supply program, the theme of “some-water-is better-than-none” must now be considered seriously for this program. Also, although the low output of 50mm cylinders was frowned upon by many users of Bush Pumps in the early trials, most Bush Pumps in the rural areas do not demand a high output of water. The number of users of Bush Pumps varies enormously from a few families to many hundreds of people. There is room therefore for further development which take account of this variation depending on setting, the quality of the water and the potential number of users to be served. In fact the water delivery rate of the unit now on trial, of around 18l/min is satisfactory for many if not most situations in which the Bush Pump finds itself. The refinements described in this manual/report have helped to improve water output of the 50mm system. And further improvements are possible.

The fact remains that if open top cylinders are used, the downtime (when a pump is not operational) can be reduced significantly, simple because worn piston seals, which account for a high proportion of maintenance procedures, can be replaced with relative ease and with little equipment, and at little cost compared to closed top cylinder models. Using current standard down-the-hole components, the steel rising main must be withdrawn to gain access to the seals. And the pipes and rods are drawn out and disconnected together, 3m at a time – which slows and complicates the procedure further.

On the international front, the Afridev hand pump, distributed widely in Africa uses a 50mm open top cylinder with a low water output compared to the 75mm cylinder output. Yet it has proved popular because it is easy to maintain and uses a non-corrosive rising main. Compared to a 75mm cylinder the 50mm diameter cylinder capacity for a given length is about 44% and is 71% for the intermediate 63.5mm diameter cylinder. This means, in simple terms, that it will take twice as long to fill a bucket of water. But perhaps that is better than not being able to fill the bucket at all! The popular India Mk
Pump series has also included models with 50mm cylinders, although the 63.5mm is standard and used with 32mm steel rising main in the Mark II and 65mm steel rising main in the open top Mark III. In more recent developments of the India Mk pumps, high quality, thick walled PVC pipes are also available as rising main material. These are especially useful for use in aggressive water.

There may be other advantages too in using high strength PVC. The great weight and cost of steel pipes, especially the 65mm GI pipe has not helped the popularity of this design. The India Mk II closed top 63.5mm cylinder design remains the most popular of the Indian pumps. This is partly due to the fact that the Mark II uses 32mm GI pipe and not 65mm pipe like the Mark III. This is possible because the rod of the India Mk pumps moves up and down vertically without any lateral movement. Lever action pumps like the Afridev and “B” type Bush Pump produce a lateral movement of rods as well as vertical movements which require a wider rising main.

Even when we consider PVC pipes, which are much weaker than steel pipes, the weight of water held in larger diameter rising mains (say 75mm) will be much higher than in smaller diameter rising mains (say 63mm). In fact the weight of water is increased by a factor of about 1.5 for any length of pipe if one compares the capacity of 75mm pipes with 63mm pipes. Thus smaller high quality thick walled (class 16) rising main pipes (say 63mm) may offer technical advantages compared to 75mm pipes since the combined weight of pipe and water is far less in the smaller pipe. This in fact will provide a beneficial factor which helps sustain the integrity of a PVC pipe, although the final delivery of water will be less. Such a concept has merit. In fact the water output of the pump described in this report is quite acceptable – it delivered enough water to fill a 9 litre bucket in about 30 seconds. In fact a rather satisfactory output for many if not most situations in which the Bush Pump finds itself.

The method of connecting the lengths of 63mm PVC pipe and joining them to the pump head and cylinder is the same as that used with the 75mm pipe used in earlier work (see reference). The bonus in this case is that the 63mm PVC pipe to 50mm thread adaptors are mass produced as PVC units and available on the market in Zimbabwe. These are ideal for experimental purposes, although units made of stronger plastic material may be required when this concept is used at greater depths. But the same equipment might be used to extrude the same product in a higher strength plastic material.

Lifting PVC rising main pipes is made much easier, compared to lifting steel pipes, simply because they are lighter. Also the combined use of a rope attached to the cylinder which can be pulled through an “eye” in the pump head in combination with those handling the pipe itself makes lighter work. In addition, lifting the 63mm PVC pipe is also made easier by the use of a bailer to extract water from the rising main before it is lifted. In this case a 50mm bailer is used on the 65mm pipe, just as a 63mm bailer is used on the 75mm pipe to remove water held in the rising main before the pipe is extracted, thus lightening the total rising main weight.

The other factor of importance when considering delivery of water is the so called slip of water through the valves during the pumping cycle. This natural slip of water, which takes a reverse direction as the poppet valve closes, reduces the efficiency of valve activity and the final delivery of water. Leaky pipe joints will also reduce the level of water in the rising main and reduce output. Also leaky foot valves reduce efficiency and output. When a foot valve is leaky, extra pumping effort is required to allow the water to regain its level at the top of the rising main column after a period of inactivity. This leads to unnecessary wear on both the pump and the user. Leakage on the foot valve must be cut to a minimum and this requires the careful manufacture and fitting of suitably poppet valves and corresponding rubber seats at the valve interface. In this description a heavy duty brass foot valve with large brass poppet and rubber seat has been used (see “B” Type Bush Pump specifications). To reduce ingress of particles which may increase leakage of the brass poppet/rubber seat interface, stainless steel screens have been found useful when fitted both above and below the poppet. A return spring has also been added above the valve. The spring, ideally made of phosphor bronze, reduces water slip and also provides a better water seal between valve and rubber seat. Leakage is thus reduced. This method was first used by the American Myers Company on their pumps in the 1880’s.
As far as the cylinder material is concerned most cylinders used in current programs are made of brass. In the experiment described here, a 50.8mm (ID) diameter, 600mm long Zimbabwean brass cylinder has been used, swaged at both ends and threaded to accept the type of thread used on both the 50mm NB GI rising main pipe and the Zimbabwean heavy duty brass foot valve manufactured with a female threaded connection of the upper housing. The original 50.8mm internal diameter cylinder was fitted directly to a heavy duty foot valve as it is in the present case. The 50.8mm diameter cylinder was used in this trial because it was available to the writer for trials. In a recent development, a 500mm length of the brass cylinder tube has been bonded within a similar length of 63mm class 16 PVC pipe with each end fitted with 63mm PVC pipe to 50mm thread adaptor. 50mm diameter brass tubing will be used for the cylinder in continued trials.

Another potential problem of combining PVC rising mains and steel pump rods is the wear of the rod on the pipe, which may be considerable if the borehole is not vertical – not an unfamiliar situation. Thus steel rods or their couplings fitted within PVC rising mains must be fitted with rubber or PVC sleeves which help to separate steel from PVC and reduce wear on the PVC pipe. Rods can also wear through steel pipes too, especially on curved boreholes. This makes the pump harder to work and increases wear and friction. The quality of the borehole is paramount to the proper functioning of the pump, whatever type it is. It is essential that all joints in the rising main are bevelled to allow easy passage of the piston seals as they are taken out and placed back.

In this report/manual the use of 16mm mild steel pump rods has been retained. 12mm stainless steel pump rods have been used in earlier trials, but the units tested tended to flex in use and without care bent when they were extracted. 16mm rods to not do this. Also the working length and diameter of the 16mm rod threads is greater than the 12mm rods previously tried and therefore stronger. A new method of connecting 16mm rods has been developed to eliminate the lock nut system and overcome the rusting of the rod threads – a method which has been on trial in aggressive water and looks promising. In less aggressive waters this new 50mm open top cylinder design could also be tested with 50mm NB GI pipe, although the cost and weight of the GI pipe is far greater then PVC pipe and also prone to some corrosion. The upside being that rod centralisers would not be necessary. The basic aim of the current method under investigation is to ease the burden and cost of piston seal replacement.

Also whilst standard 50mm NB GI pipe can be used with the brass equipment (cylinder, piston and foot valve) described here, the use of quality PVC pipes must be tested again, especially for use in areas where the water is aggressive. It is hoped that by adapting to these alternative “down the hole” components and after suitable trials have proven the method successful, that the delivery of water from the Bush Pump will become far more reliable and “down time” much reduced. It is for this reason that the writer, who is now retired, continues to perform these trials in his back yard to work out the best methods of moving forward for the benefit of those who depend on the pump.

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A Bush Pump in Epworth close to Harare. The Bush Pump is Zimbabwe’s national hand pump and has its origins in Plumtree, Matabeleland, Zimbabwe over 80 years ago. It has been described in many previous manuals which can be read on the Aquamor website www.aquamor.info
New designs on trial

Modification of pump head to suit a 63mm PVC rising main and 50mm cylinder

The pump head itself remains unchanged apart from the modification of the dip plug hole in the rising main support plate. This hole is opened up and smoothed down to allow access to ropes which are fitted to the lower part of the cylinder and assist in lowering and raising the rising main pipes. The standard heavy duty 50mm steel socket welded to the bottom flange plate of the water discharge assembly is the version used to support the 63mm class 16 PVC rising main. Currently all standard Bush Pumps use a heavy duty 50mm socket welded to the bottom flange plate of the water discharge assembly to carry the 50mm NB GI rising main pipes. So an adaptation to the PVC option is easy if the trials prove successful. During lowering and lifting of the 63mm PVC rising main, a pipe holder is used to secure the pipes during the connecting procedure.

The standard dip plug hole in the rising main support plate has been opened up to allow access to support ropes attached to the cylinder which greatly assist the lowering and raising of the PVC pipes. As the pipes are lowered or raised they are held secure with a rising main pipe holder whilst the pipes are joined. The pipe holder supports the pipe connectors as shown.

The 63mm class 16 PVC rising main

The rising main is made up of lengths of high quality 63mm class 16 PVC pipe, which is sold in standard 6m lengths in Zimbabwe. If 6m lengths are too long to carry, the length can be cut in half and the non-belled end of one half solvent cemented into the belled end of the other half to remake a 6m length. On site the 6m lengths can be used. They can be shortened or lengthened using PVC pipe connectors. The end of each PVC joint is chamfered to allow for easy passage of the piston within.

The 63mm PVC pipe joints

At this stage in the experimentation standard PVC adaptors (63mm PVC to 50mm pipe thread) are used together with 50mm GI barrel nipples. Barrel nipples will be made of brass in future to prevent corrosion. The adaptors are also made of PVC, but stronger plastic materials should be used in future. These experiments are regarded as trials only. Marine Silicone Sealant has been used to seal all threaded joints.
In the trials, all the components used in the rising main assembly are standard items. 63mm class 16 PVC pipe, PVC 63mm PVC to 50mm thread adaptor and 50mm GI barrel nipple.

**Linking the upper pipe joint to the Pump head.**

The complete upper end of the PVC 63mm pipe must fit through the adaptor described above. The 50mm barrel nipple is threaded into the heavy duty 50mm GI socket welded to the bottom flange plate of the water discharge assembly. This normally supports the 50mm NB GI rising main pipes.

**Joining the lengths of pipe**

6 meter (or shorter) lengths of 63mm class 16 PVC pipe can be joined in the following way using standard off the shelf components for the trials. These components consist of standard 63mm PVC pipe connector on one end and a 50mm thread for steel fitting on the other end and a standard 50mm steel barrel nipple. 50mm brass barrel nipples are planned for future work, since these do not corrode like steel. In the current trial the steel barrel nipples are painted with red oxide in and out to prolong life. Brass is an ideal material for the 50mm barrel nipples. Marine Silicone Sealant is used on all threaded joints. It is a good sealant and helps to prolong the working life of the threads, and make them easier to separate.

The method of joining lengths of 63mm PVC pipes in this trial using standard parts. (63mm PVC to 50mm thread adaptors and 50mm GI barrel nipples – red oxide coated). Brass or stainless steel barrel nipples will be used in future. Marine Silicone Sealant is used to seal joints.
The cylinder

Several 50mm cylinder options are possible, and the joint between rising main pipe and cylinder depends on what option is chosen. In this current trial a Zimbabwean 600mm long 50.8mm (ID) brass tube, swaged and threaded at both ends to fit 50mm steel thread fittings or PVC thread has been used. The length of 600mm was taken from the length of the standard 75mm cylinder, which allows for cutting back and rethreading the inside threads as they wear and also for some variation in rod length. However the length of the 50mm cylinder could be reduced to 500mm, allowing for 50mm on each end for swaging and threading on both ends to make a working length of 400mm. The stroke length of the Bush Pump is long compared to many pumps at 225mm. In earlier times this cylinder was used in combination with the heavy duty foot valve mentioned earlier.

Left: The Zimbabwean brass cylinder tube is 600mm long and swaged at both ends. The Bush pump has a long stroke compared to many hand pumps – 225mm. Long cylinders are therefore required. Right: The brass cylinder fitted directly to a heavy duty foot valve below (with female thread fitting).

Alternative cylinder assemblies

The method of bonding a brass or stainless steel cylinder tube within a PVC pipe is also a good option. This method is used on the Afridev hand pump. In this case the brass tube similar to the one shown above has been cut down to a length of 500mm with the ends smoothed off and pushed within a 63mm class 16 PVC pipe using Pratley quickset White as a bonding agent. 63mm PVC pipe to 50mm thread adaptors are bonded to end of the tube. This makes a low cost and effective cylinder arrangement. The upper adaptor thread can be screwed into the barrel nipple linked to the upper pipe, and the lower adaptor thread screwed into a heavy duty foot valve equipped with either a female thread (through a barrel nipple) or the standard heavy duty foot valve used in Zimbabwe with a male thread.

The cylinder assembly using a brass tube bonded within PVC pipe with threaded end caps

63mm PVC pipe to 50mm thread adaptors are bonded to end of the tube.
The Piston
The 50mm piston used in this trial is a locally made unit and similar in many ways to the India Mk II/III 63.5mm units, but designed to accept a 50mm nitrile rubber seal and a 16mm thread for the pump rod. Nitrile rubber seals must be of the highest quality, as all hand pump seals should be. These nitrile rubber seals are the same as used on the Afridev hand pump and were kindly sent to me by Karl Erpt of SKAT many years ago. They are now standard equipment used with the Afridev hand pump.

The India Mk brass piston poppets use a rubber seat attached to the poppet valve, a well tried method which may reduce was slippage in the piston. Zimbabwean piston poppet valves have, so far, not used a rubber seat. Heavier poppets also close more quickly and may reduce slippage which is an advantage when smaller diameter pistons are used. In the current trial the diameter of the barrel of the piston body has been increased slightly, so that a standard 50mm nitrile rubber seal will fit neatly into a 50.8mm cylinder. Further trials will use 50mm cylinders and pistons which can accept at least 2 seals.

Smaller 50mm nitrile rubber seals may wear out more quickly than the larger 75mm leather seals used on the current standard Bush Pump, but with the open top cylinder they are more easily replaced.

The foot valve
This is the high quality heavy duty brass unit fitted to all Bush Pumps. If properly made it is very durable and has a long life. The poppet valve is fitted with fins which make the valve rotate in use. The poppet sits on a rubber ring which forms a good seal if properly mounted and tested. The rubber wears down slowly, but has a life of several years. In a modification of the foot valve stainless steel screens are fitted both above and below the poppet valve. This is an attempt to avoid the possibility of foreign objects which may cause leaks becoming trapped in the vital foot valve. It is essential to ensure the poppet valve is mounted perfectly over the rubber ring to avoid leaks. In addition a poppet return spring has been fitted between the upper housing of the foot valve and the poppet. This spring system was first developed and used by the Myers Company, Ohio, USA, in the 19th Century to reduce the so called “slippage” (loss) of water as the poppet valve returned to its lowest position. This spring improves the efficiency of the valve, helping to reduce leakage and thus increasing water output. Any method of increasing the output of the 50mm cylinder (when compared to a 75mm cylinder) is seen as an advantage.
The three main components of the brass foot valve (lower housing, poppet valve and upper housing). The poppet valve rests on a rubber ring held in a slot formed in the lower housing of the assembly. To avoid debris entering the lower poppet cage (and causing leaks) stainless steel screens have been fitted within the cage. A disc of stainless steel screen is also bonded to the upper component as shown. This helps to avoid foreign objects that fall down the rising main from entering the vital interface between poppet valve and valve seat. Pratley’s White has been used as the bonding agent between screen and upper housing (which has kept the screen intact for a period of more than 2 years so far in trials).

The poppet and the screened upper component of the foot valve. The poppet return spring sits within the fins of the poppet and is compressed by the stainless steel screens (two layers of screen can be used) held within the upper component. The upper and lower components of the foot valve are screwed together, thus compressing the spring. A good seal at this point is essential. Marine Silicon Sealant has proved the best sealant for this application, and also the threaded joints of the rising main. Perfectly made foot valves need no sealant as the brass faces of the components should fit together perfectly, but this is rarely the case. It is always a wise precaution to use a good sealant on all joints threaded joints. It is important the test the foot valve for leaks before installation.

Reducing leaks in the foot valve and rising main to a minimum

With all hand pumps, the integrity and correct functioning of the foot valve (and check valve if fitted) is essential, as water slippage or leakage of these valves will adversely affect pump performance and wear. This is especially true for open top cylinder models as it is assumed most of the routine management of the pump will involve seal replacement, which can easily be undertaken by lifting the rods and piston only. Foot valves are expected to work, almost without maintenance, for years without being attended to.

To make this possible, the foot valve must be made strictly according to specifications with all interfaces between parts (upper and low housings and poppet valve – rubber seat) being perfectly fitted to avoid leaks. After production the foot valves should be thoroughly cleaned to get rid of cuttings and also the valve should be tested for leaks. Also the foot valve must be fitted carefully to ensure that all potential leaks are overcome. Even when a foot valve has been tested in the workshop, it may develop leaks after it has been fitted to the well or borehole. These leaks can be caused by materials falling down the rising main during the installation process. Any items falling down the rising main have the potential
Efficiency of the foot valve.

Whilst poorly manufactured or poorly installed foot valves can significantly reduce the efficiency of valve performance, there may be other reasons which reduce valve efficiency. Over a hundred years ago (in the 1880’s) the American company Myers, in Ohio, had been making borehole pumps and equipment and it is very likely that some of the brass components used in current valve and pumping gear have their origins with Myers designs. It is interesting to note that in these early designs phosphor bronze springs were used both on the check valve (foot valve) and the piston valve to increase valve efficiency by reducing leaks and slippage of water. This same innovation has been used in Grundfos hand pump foot valves. In the configuration shown above a similar spring has been used to improve the efficiency of the Zimbabwean foot valve.

The cylinder has now been threaded into the upper housing of the foot valve. Marine Silicone Sealant has been used as a thread sealant. The threads are done up tightly with wrench spanners. The upper cylinder thread is screwed in to the PVC adaptor and also sealed with Marine Silicone Sealant.

Leak tests on the spring loaded foot valve fitted directly to the cylinder reveal almost no leakage over an hour period and only 20mm over an 18 hour period. Left photo: cylinder filled. Middle photo – water level after an hour. Right photo – water level after 18 hours. Marine Silicone Sealant was used to seal the upper and lower housings of the foot valve and also the threaded joint between foot valve and cylinder. These photos were taken an hour apart after the cylinder was filled with water. The loss of water was minimal.

Use of Marine Silicone Sealant

This material is available in tubes for about US3.50 per tube. This is enough material for sealing many threaded joints. After the male and female threads have been cleaned and dried, the sealant is applied by finger to the both the male and female threads thinly, so as to just fill the grooves of the thread. No excess should be used. Then the two components are threaded together using a wrench spanner to make a tight joint. This material never sets solid, so the joint, whilst well sealed can be unscrewed when required and also protects the threads. This sealant can also be used on the rod threads.

Marine Silicon Sealant
The 16mm steel pump rods and rod connectors

Both 12mm stainless steel and 16mm mild steel rods have both been used in trials. The 16mm rods proved superior, as the 12mm rods, whilst lighter and non-corrosive, tended to flex in use and the thread were shorter, narrower and therefore weaker than the 16mm threads. Therefore 16mm mild steel rods (which are standard for use on the Bush Pump) were chosen for continued development. Improvements have been made to the jointing and protection of the commonly available 16mm mild steel rods and currently this method has been chosen as the ideal rod for this purpose in trials. Although the 16mm mild steel rods are heavy they provide a smooth action during pumping. The 3m lengths of 16mm rods are linked through 65/66mm long steel connectors. The method using the connector has been modified to dispense with the use of lock nuts and reduce the effect of rusting on exposed threads. Threads on either end of the rod are made at different lengths. The longest thread is 96mm, so that when the connector is fully attached a section of 30mm of threaded rod protrudes from the end of the connector. On the other end of the rod the threading is shorter, just short of half the length of the connector being 30mm. On this side the connector is threaded on the rod so that just over half the length of the internal connector thread (female thread) is ready for the male thread on the other rod to be fitted. The connectors are welded to the rod on the inner interfaces. This method avoids the use of lock nuts, which expose threads to rusting and resulting problems. In the prototype the rods have been painted with red oxide, but they should be galvanised throughout. In order to protect the PVC rising main pipe, PVC bushes, or sleeves have been pushed over the steel connectors. Future development could include the use of 12mm stainless steel rods, but they are not available in Zimbabwe.

Connecting the 16mm rods (as described above). The joints before treating with red oxide. This method has been on trial for over a year in aggressive waters and appears to be effective at protecting the corrosion of the threads within the steel connector. To avoid rubbing of the steel rod on the plastic rising main a plastic guide should be fitted to each length of rod. In this case a standard 25mm PVC connector has been heated in boiling water, which softens it slightly, and the steel socket is pressed over the PVC connector. This method of covering the steel connector avoids the immediate contact of its cornered edges to the internal wall of the PVC rising main pipe. When there is wear, it is PVC against PVC and can be inspected when the rods are removed for seal replacement. These photos show a prototype.

Prototype 16mm rod joint with rod and pipe protector
Assembling the rod and pipe components on the ground

Fitting the “down the hole” components takes place in two stages. First introducing the combined foot valve, cylinder and PVC rising main attached to the water discharge unit of the pump head. Second, the introduction of the piston and pump rods into the rising main and attachment to the U bracket of the pump head. These are best cut and assembled on the ground first to ensure they are well prepared and matched for insertion. The rods coupled with the piston are assembled to match the length of the rising main. The upper end of the rod screws into the U bracket of the pump head. Current trials are being performed on relatively shallow wells. The lengths of the rod and pipe are chosen to match the depth of the well (in this case) or borehole in other cases. The length of the pipe and rod must be carefully matched to ensure that the piston moves up and down within the working barrel of the cylinder. In current standard practice the piston is raised about 50mm above the bottom of the working length of the cylinder.

Once the length of the rising main and rods have been established the pipes and rods are assembled on the ground. The water discharge unit, floating washer housing and upper rod linked through the floating washers and U bracket are laid on the ground as shown in the photo below. The rods and pipe built up together the match the depth of the well or borehole.

The upper end of the rising main and rods as laid out on the ground. Future trials will use brass barrel nipples which will not corrode like steel.

Left: The complete rising main and rods used in the trial laid out on the ground. Middle: The lower end with cylinder and foot valve in place connected to the PVC rising main through the 63mm/50mm thread adaptor. The piston and nitrile rubber seal with red oxide coating of the pump rod. The lengths of rod and pipe are adjusted so that the piston comes to lie about 50mm from the bottom of the working length of the cylinder.
Chamfering the pipes and couplings and solvent cementing

In order to allow free lifting and lowering of the piston within the rising main and its couplings the inner walls of the pipes and barrel nipples and all squared ends held within the coupling must be chamfered, so that the piston seal meets no squared ends on its way up the pipe on removal.

Filing down squared ends on pipes (and also on barrel nipples). Solvent cementing PVC joints. This is a crucial procedure and carried out with fresh solvent cement. The surfaces are roughened slightly with fine sand paper and then the solvent cement is applied to both internal and external surfaces. The two parts then pushed into each other with a rotational motioned. Excess solvent cement is clean off with a rag. The solvent cement actually dissolved the outermost surface of the PVC components exposed to it. Once solvent cemented, the parts are left for a few hours to set properly.

Installing the pipes and rods

The pump head will have already been fitted and bolted to a 150mm diameter steel tube mounted in concrete on the well slab (or borehole). The first length of 63mm PVC rising main will include the cylinder, and foot valve with supporting ropes attached around the cylinder. The rope is useful as it can be used to both lower and lift the PVC pipes to assist the pump mechanic who handles the pipe directly. The rope slides through the opening in the rising main support plate where the sharper edges have been smoothed off. This hole also serves as a dip plug hole where the water level in the well or borehole can be checked.

The twin ropes of durable material are bound securely to the cylinder and are long enough to reach the pump head and at least half a meter beyond. The lowest pipe with cylinder, foot valve and rope attached is taken to the pump head. On the right, the cylinder and foot valves are about to be lowered down through the pump head into the well. The rising main is lowered by 2 people, one holding the pipe and one holding the rope which passes through the smoothed opening in the rising main support plate.
The lowest pipe segment with cylinder and foot valve together with support ropes are lowered down through the pump head. This can be performed by one person holding the pipe and another holding the rope, although 3 or 4 people would be best depending on the depth and total weight of pipes and rods. The pipe is lowered until the first pipe joint appears. The pipe holder is then inserted and this holds the pipe secure whilst the next pipe is fitted. The threading at the pipe joints must be well sealed with Marine Silicone Sealant.

The next pipe to be inserted is 6m long. It was stabilised on the pump headworks first, then placed on the rising main support plate of the pump head. Then carefully screwed into the 50mm steel barrel nipple below. The barrel nipple was held with a pipe wrench and the PVC pipe turned by hand. Once again Marine Silicone Sealant was used to seal and protect the threads.

The final length of 63mm PVC rising main has an expanded section solvent bonded to it about 1.5m below the top adaptor. This expanded section is made of a PVC pipe connector, smoothed down internally and cut in half and solvent bonded to the main pipe. The pipe is held up by this expanded section on the pipe holder whilst the water discharge unit of the pump head is screwed into the uppermost 50mm barrel nipple.
Securing the rope and lowering the water discharge unit.

The rope which has been used to help raise and lower the rising main is now tied underneath the bottom plate of the water discharge unit. The water discharge unit is then lowered onto the rising main support plate of the pump head and bolted in position.

Lowering the piston and rods down through the rising main.

The 50mm piston and each length of 16mm red oxide coated rod is lowered down the rising main pipe and held by a special rod holding tool. In this prototype the thread and lock nut holding the piston have been coated with red oxide. The rod holding tool is used to both support and hold the rod in position whilst the connector of the rod above is being screwed into the protruding threaded section of the rod beneath.

The upper rod connector at each joint has been pushed through a heated 25mm PVC sleeve. This PVC sleeve helps to reduce wear on the rising main pipe caused by the steel connector. The two pump rods are screwed together tightly within the steel connector by using an adjustable spanner. A little marine silicon can be applied to the thread. Using this method, over a year of testing has shown that the threads do not deteriorate even in mildly aggressive water.
Each rod is lowered in turn, the last holding parts of the floating washer housing and the U bracket above.

The bolts holding the floating washer housing are inserted and tightened. The rods are secured to the main U bracket which is held up and buffered by a stout rubber buffer. The rod passes through the centre of two circular discs known as floating washers, one inside the housing and one above the housing. These move about during each pump stroke to accommodate the position of the rod within the rising main pipe. The rubber buffer rests on top of the upper floating washer. This system provides a direct link between the piston, through the rods to the wooden block which acts as a lever and bearing.

Fitting the wooden block

The next stage involves fitting the wooden block, which acts as a combined bearing and lever. This system is characteristic of all Bush Pumps, since they were first developed in 1933. The teak block is boiled in oil after it has been cut and drilled. The block is supported by two large bolts called “pivot pins.” One pivot pin is attached to the steel pump frame and the other to the U bracket which supports the pump rods. The pivot pins are held secure by nuts held tight by sturdy spring washers. The pivot pins appreciate being greased from time to time. But they are the only part of the pump which requires greasing. All parts of the “B” type Bush Pump head are rugged and designed to accept a heavy duty life. The wooden block has a long life and has two sets of working holes to prolong the life further.
Fitting the wooden block

The pump head as the wooden block is being fitted. The two 35mm diameter steel pivot pins with nuts and lock washers. The pivot pins should be greased occasionally.

![Image of wooden block being fitted](image)

The pivot pins pass through the head and U bracket. They are held in place on one side with head bolt stabilisers.

![Image of pivot pins](image)

On the other side they are held tight with nuts and thick lock washers. A special spanner is used to lock the nuts tight. The handle is made from a standard GI pipe. Its length and diameter depends on the depth to which the pump is required to pump. Once the bolts are tightened the pump can be tested for water flow. A 50mm piston should deliver a 9li bucket of water in about 30 seconds. But delivery rate depends on the energy of the user. The standard 75mm cylinder will deliver over twice as much water, but is more difficult to maintain.
The rising main bailer

63mm PVC rising mains are light, unless they are filled with water. Then they become much heavier. Galvanised iron rising mains are much heavier still. Whilst it is hoped that the rising main may rarely need lifting out (compared to the rods and piston seals) there are occasions when this is necessary. This may be when the foot valve becomes too leaky, or when a rod or foot valve becomes disconnected, or when the PVC rising main becomes damaged. In these cases the rising main may not be full of water, but the extraction of the pipe is made easier by removing the water inside it. This can be achieved with a “Bailer-bucket” system. 50mm PVC pipe is used to make the Bailer-bucket for the 63mm pipe (just as 63mm pipe was used as a bailer bucket for the larger 75mm PVC rising main pipe (see reference). The 50mm PVC bailer pipe is fitted with a small brass non-return valve at the lower end (encased in hard setting putty plug) and a wire handle at the upper end is used to attach the bailer to the rope. The bailer should be about 2m long. It is a simple and valuable tool. It simply lightens the weight of the rising main, by removing water, and makes it much easier to pull out by hand (or by a combination of rope and hand). If all else fails with the pump itself the bailer-bucket can be used to extract water from the rising main and place it in a bucket!

A half inch (12mm) brass non return valve is used in the bailer. This is embedded in a plug of hard setting putty using a small section of the 50mm pipe as a mould. This plug is bonded into the base of the bailer. A small rod is passed through a hole made through a double thickness of pipe at the top of the bailer. The rope is attached to this.

The rising main “bailer-bucket” which can remove water from the rising main pipe before the pipe is pulled out. This makes the pipe and its contents much lighter and consequently the pipe is much easier to lift. The rising main pipes are lifted (and lowered) by using a combination of holding and lowering the pipe by hand with support from the rising main rope. When used in combination the pipes can be lowered and raised with precision.
Tools used for the 50mm open top cylinder model of the Bush Pump

Selection of tools used for open top cylinder Bush Pump management.

Current trials
The pump described here is on trial. Currently the PVC jointing, rods, links between PVC pipes and pump head and cylinder, sealants, valve units and the special tools are being monitored and where necessary improved. When a level of satisfaction has been reached the testing can be extended to introducing prototypes into heavier duty and deeper sites in the field to further test the concept. The main areas of investigation concern the method of connecting the pipes and the strength of PVC to hold up the weight of the water in the column. For this work type of work it is essential that high quality thick walled PVC pipe is used. The initial testing was carried out at Epworth, and then transferred to the writer’s back yard to modify and improve concepts, components and methods and refine specialised tools. The aim here is to attempt to use parts which are currently available within Zimbabwe. However one part, the crucial 63mm PVC to 50mm thread adaptor, whilst currently available in Zimbabwe is made of PVC. At greater depths than those which are currently being tested, this same unit should be made in a stronger plastic material than PVC. Also improvements could be made to the current 50mm piston such as the use of a double, or even triple nitrile rubber seals and a heavier poppet valve, possibly with a rubber seat of its own.

Water tight seals are required in all the valves used and also at the threaded joints throughout the rising main system which hold water and protect the threads. Whilst Plumbers Thread Sealant has been used as a standard sealant for decades, the use of Marine Silicon Sealant shows great promise for use in the system now being tested. It has been used throughout the system, both on pipe and rod connections. It provides a good seal and protects the threads and allows parts to be dismantled with ease. Only small amounts are used to seal the threads. In current trials almost no water is lost due to leakage.

I thank John Norman of Diesel and Plant for fabricating the first pipe holding tool and various other components in the initial trials with a 75mm PVC rising main. I also am indebted to Oswald Chakauya, my talented gardener for his most valuable assistant in performing tasks that the more elderly (like me) find either tiring or impossible. The development and trials of this version of the Bush Pump continue. The intention is to develop the pump further, so it becomes simpler and cheaper to maintain and is thus able to provide an improved service to those Zimbabweans who depend on it for their vital water supply. PVC cannot work at great depths, but current trials in other countries suggest that it may have value down a depth of between 30 and 40m. Or even more! In less aggressive water the 50mm open top cylinder can also be used with standard quality galvanised iron pipe, but with the combined constraints of cost, weight and corrosion. As for the outcome – “Only time will tell.”

Further reading from Aquamor website
The Zimbabwe Bush Pump. Recent developments using the 63.5mm open top cylinder version with PVC rising main and 16mm pump rods. (2015).
A large number of written works on the Bush Pump and other areas in water and sanitation can be found on the Aquamor website www.aquamor.info