The Zimbabwe Bush Pump

Recent developments using the 63.5mm open top cylinder version with PVC rising main and 16mm pump rods

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Recent developments – 2014 -2016

The “B” type Bush Pump became Zimbabwe’s National Standard Hand Pump in 1989 following research carried out during the period 1987 – 1989. Earlier models date back to 1933. The pump head is robust and uses a hardwood block made of teak as a bearing and lever mechanism. This method has been supremely successful. The standard “down the hole” components of the Bush Pump comprise a combination of 50mm galvanised iron rising mains, 16mm galvanised mild steel rods and a 75mm brass cylinder with matching piston fitted with two leather seals and a durable heavy duty foot valve. During periods of research in Zimbabwe, “open top cylinder” models, both 50mm and 63.5mm, have been designed and tested to make the routine maintenance requirement of piston seal replacement easier, since the rods and piston with its seals could be withdrawn through the rising main to the surface. This made the lifting of the pipes unnecessary for routine replacement of seals – a rather obvious improvement. Rising mains during this experimental era 50mm NB GI pipe for the 50mm piston (which used a nitrile rubber seal), and 65mm NB GI pipe for the 63mm piston, a heavy and expensive component. Whilst these units were placed on extensive trials, standard (non-extractable) “down the hole” components remained the standard for use in national programmes.

The most common maintenance procedure for the Bush Pump is replacement of the leather seals mounted on the piston. Currently 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, but makes maintenance lengthy and cumbersome. The life of the seals depends on their quality, the amount of use, the condition of the water and also the smoothness of the internal wall of the cylinder. Some seals last for years, others need replacing within months. There is a great variation in seal quality. It is a problem requiring urgent attention.

Bush Pump in use at a school in Epworth

The open top cylinder technique, as it was conceived years ago, followed international trends to make routine maintenance (seal replacement) easier. In this concept the rising main pipe has a larger diameter than the piston seal, which means the piston can be easily lifted out through the rising main pipe. This makes the lifting of the heavy pipes unnecessary, unless problems with the foot valve occur, or the rods or piston separates or the pipe becomes leaky due to corrosion and requires replacing. The use of the word “open top” refers to the fact that the cylinder is open at the top, so the piston can be withdrawn up through the rising main pipe. Many hand pumps made in England during the Victorian era used the same principle. Whilst about 1000 units of this type were once installed in the Zimbabwe program, the method never took off nationally. This was partly due to the 65mm steel rising mains great weight and expense. Also the project had problems with piston seal quality. In addition many OTC cylinders were 50mm in diameter, which provided a poor water discharge, unacceptable to users of pumps commonly fitted with 75mm cylinders. Later, a compromise was made using a 63.5mm open top cylinder, which has an output about 30% less than the 75mm cylinder. Whilst the use of 50mm steel pipes and 75mm cylinders continues as the standard procedure, there is room for further experimentation to be carried out on developing easier maintenance methods for the Bush Pump which serves millions of people in Zimbabwe.
The current work, being carried out by Aquamor, investigates using thick walled, quality PVC as a rising main. PVC is lighter and cheaper than steel, but also weaker and PVC is known to stretch. PVC was not designed to carry heavy weights like supporting heavy water columns vertically. However work performed in other countries reveals that the method has merit, especially in situations where the pump raises aggressive water which leads to corrosion of steel pipes. The use of high quality, thick walled PVC is essential. Internationally, this work has mostly been carried out on PVC pipes of 65mm diameter, which, with skill and care, can be lifted out as a single column. This is not possible with larger PVC pipes, such as 75mm, which is required for lifting out a 65mm piston. 75mm pipes must be used in shorter lengths which will require connecting and disconnecting. The joints are therefore critical. They must be able to carry great weight and also be easy to connect and disconnect. The method of connecting and lifting PVC pipes varies somewhat – threading, stainless steel couplings and other methods are in use internationally. In addition, the use of steel rods working within a PVC rising main pipe introduced its own problems, particularly wear of the rod on the pipe. Rod guides are therefore essential to reduce the rate of wear on the PVC. It is speculated that the use of high quality, thick walled 75mm PVC pipes could operate down to a depth of between 30 and 40m.

The standard 16mm mild steel galvanised pump rods can also produce problems. They are heavy, and are liable to rusting, especially at the threaded joints. It has been a long practice in Zimbabwe to connect the 3m long rods through steel rod connectors, and tighten the joint on either side of the connector with a lock nut. This method, which has been used for many decades, is prone to rusting, especially in aggressive water and at the exposed part of the thread, where the protective galvanising is cut off. In this study improvements have been made to the standard method of connecting and protecting 16mm mild steel rods. 12mm stainless steel rods have also been tried in these experiments, but they proved to be more flexible with less thread length than the 16mm mild steel rods. The 16mm mild steel rods have been retained – the pump action feels much smoother when they are used.

Leather piston seals are used in Zimbabwe in the 75mm brass cylinder of the Bush Pump, but there is considerable variation in the quality of the seals delivered by manufacturers. Quality leather seals can last for years whilst others, of poor quality, wear out within weeks. This is serious problem which needs urgent attention. The same problems of varying quality can also occur with nitrile rubber seals used in other public domain pumps. The merit of nitrile rubber seals is that they do not expand substantially when being withdrawn through the rising main, whereas leather seals may expand when released from the restrictions of the cylinder. However if serious attention is paid to bevelling the joints within the rising main, the problem can be overcome. Quality leather seals are essential, as they run smoothly within the cylinder and also can cope with a certain degree of impurities in the water. Whether leather or nitrile rubber seals are used, a good reputable source is essential and must be chosen. Simple methods of establishing the quality of the seals need to be established.

Currently research work is being carried out on the use of thick walled high quality PVC as a rising main for the Bush Pump. This work is very challenging and combines the experience of the earlier methods, using steel components (reported in earlier manuals by Aquamor) with new techniques which are currently on trial. Continued development work on Zimbabwe’s National Hand Pump is very pertinent to the Zimbabwe rural water supply program. To keep water flowing through the pumps, the routine replacement of the vital leather seals could and should be made simpler by the adoption of an open top cylinder system, where conditions are suitable. The prolonged “down time” (when pumps do not provide water) of large numbers of pumps, which should serve the community, is partly (but not wholly) the result of a combination of the cumbersome method of replacing seals and also the quality of the seals themselves. Quality seals are available and provide an extended life span. The difference in cost between quality and poor seals is just a few dollars. The cost and inconvenience of repeated replacement of poor seals in very high. The “down time” when pumps are not operating is also highly inconvenient for the users. Continued research and development is necessary, followed by field testing and adoption when the technical challenges have been overcome.

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The Challenges

The aim of the present work is to examine the use of thick walled, quality PVC pipe as a rising main for the Zimbabwe Bush Pump, using an open top 63.5mm brass cylinder and heavy duty brass foot valve. PVC is not designed to take the strain when placed in this setting, although work elsewhere has shown that if high quality, thick walled (class16) pipe is used with suitable jointing then some success can be achieved down to depths of up to 40m. This does not cover the full range required for the Bush Pump which is expected to pump water from aquifers which may be more than 80m deep.

This work also examined the feel of the pump using 12mm stainless steel rod, as well as 16mm mild steel rod (which is the standard). Results revealed the 12mm stainless rod to be too flexible and the 16mm mild steel rod (with its more substantial threads) were retained, but with a modified method of joining the rods to avoid rusting of the threads in aggressive water.

The standard pump head (fitted with 65mm HD socket for rising main attachment) remained unchanged (fabricated according to the National Specifications) with one modification. This is the opening up of the dip plug hole on the rising main support plate to allow access for the ropes which are attached to the base of the rising main and assist in lowering and raising the rising main.

The greatest challenge has been the jointing of the thick walled 75mm PVC pipes, used as the rising main. These pipes are relatively low cost and light, but not as strong as steel. Work on this subject has taken place elsewhere (in India, for example, for the India Mk II and III pumps) and reports are available from the RWSN websites. 75mm pipe must be used so that extraction of the 63.5mm piston can be achieved. But 75mm pipe must be assembled in sections. The latest work, described here reveals that pipes can be assembled in 6m sections and fitted by a minimum of two people for shallower depths, but four people is desirable. Various methods have been tried during earlier trials in the current research programme to connect the lengths of pipe and these include: 1. Stainless steel bands used in the packing industry (Band-it), to link and support the rising main - top to bottom. 2. Using Band-it and brass collars to connect each pipe joint. 3. Using threaded couplings on the ends of each PVC pipe length joined with a barrel- nipple technique at each joint. These adaptors are threaded on one side and allow bonding to a 75mm pipe in the other.

The ideal material for making the plastic couplings which are bonded to each end of the PVC pipe is HDPE. This is stronger than PVC and able to take the strain through threaded joints. It can be bonded to PVC. The original HDPE coupling unit was fabricated by John Norman of Diesel and Plant Pvt Ltd for linking the cylinder to the pipe, but it has far more reaching application. Further PVC units modelled on the HDPE unit have been fabricated by Protorite Ltd, for trials. Initially GI barrel nipples (red oxide coated) are being used, but they introduce steel components it the rising main system and brass barrel nipples are preferred. An effective seal is essential at the joints (and within the cylinder/foot valve and rising main systems and Marine Silicone Sealant has been found to be the most effective. Also the steel pump rods must be fitted with plastic or rubber guides to reduce wear of the rod on the PVC pipe.

The use of quality stainless steel tube as a cylinder material has also been tested in Zimbabwe in the 1980's and provided good service. The high quality working surfaces of the tube and the use of high quality nitrile rubber seals gave a seal life of between 5 and 6 years working in a communal setting – an improvement on the equivalent leather seal and brass tube combination. Stainless steel tubes, with their hard and highly polished internal surfaces can be bonded to the inside wall of HQ PVC pipes and this type of assembly is also being considered for testing. Whilst the well tested heavy duty brass foot valve provides excellent service, a simpler lower cost but hard working and reliable unit can also be considered for PVC pipe rising mains, since pumps fitted in this way – do not demand holding water beyond 40m – the standard heavy duty foot valve – holds water up to 80+ metres.
New designs on trial

Modification of pump head to suit a 75mm PVC rising main

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 pipes. The variant described in the National Specifications, using a heavy duty 65mm NB socket welded to the bottom flange plate of the water discharge assembly. Currently all standard Bush Pumps use a HD (heavy duty) 50mm socket welded to the bottom flange plate of the water discharge assembly to carry the 50mm steel rising main pipes. A 65mm socket is used to carry 65mm steel rising mains used on former 63.5mm open top cylinder models. The great weight of the rising main includes the weight of water – and this is considerable in rising mains with increased diameter like the 75mm version. In these pumps with 75mm PVC rising mains, water is removed from the rising main using a bailer before the pipes are lifted, as this considerably reduces the total weight of the rising main assembly.

The PVC rising main and its joints

The rising main is made up of lengths of high quality 75mm PVC pipe. The standard length is 6m for PVC sold in Zimbabwe. Class 10 and 12 pipe have been used in the initial trials but Class 16 is the preferred option. Class 12 pipe has a wall thickness of 2.7mm and class 16, 3.5mm. The technique of connecting PVC pipes together varies a great deal internationally. In the case described here, the ends of each PVC pipe are bonded to a coupling which is threaded on one side and cemented to the pipe on the other side. The pipes are joined using a threaded barrel nipple. In initial trials the barrel nipple has been made of steel, painted with red oxide. Further development using durable plastic components is still required. Stainless steel is currently considered too expensive.
Couplings made from PVC (white and blue) and HDPE (grey)

75mm PVC pipe with couplings fitted on either side (demo) with threaded barrel nipple (pre-coating) on one side and the thread of the open top brass 63.5mm cylinder on the other side. Marine Silicone Sealant has been used to seal the link between foot valve and cylinder and cylinder and PVC adaptor.

Link between PVC pipe and pump head

The coupling of the uppermost PVC pipe is linked to the pump head through a barrel nipple (in this experimental case a steel barrel nipple painted with red oxide).

65mm red oxide coated barrel nipple threaded into the 65mm heavy duty steel socket of the water discharge assembly of the pump head. A brass barrel nipple is the preferred material. Note the rod and the pipe are assembled together on the ground first to get a good match between pipe and rod length.
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. In the standard 75mm cylinder unit of the Bush Pump, a check valve is fitted at the base of the cylinder in addition to the foot valve. This effectively provides the system with 2 foot valves. The current system has a single foot valve like most hand pumps. 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 (in this experiment) 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 63.5mm cylinder (when compared to a 75mm cylinder) is seen as an advantage.

Water tight seals

To increase efficiency of the whole foot valve, cylinder and rising main unit, all the joints should be free of leakage. Marine Silicone Sealant is the most effective. All joints should be checked for leakage before the rising main and its components are placed down the well of borehole.
The cylinder

The cylinder is a 600mm long 63.5mm ID brass tube, swaged and threaded at both ends to fit a 65mm NB steel pipe thread fitting on the upper end and a 50mm NB steel pipe thread fitting on the lower end. The heavy duty foot valve with female upper thread is used.

Fitting the parts and testing for leakage

The success of the system depends on the lack of leaks of the foot valve and its link to the cylinder and rising main has no leaks. Since the upper and lower housings of the foot valve are rarely completely water tight when screwed together (as they were designed to be) the application of a thin layer of sealant on the threads before connecting will provide the essential seal. This seal is best made with Marine Silicone Sealant. Very little sealant is required and should be applied to both male and female threads before they are screwed together. This also applies to the threads between the foot valve and the cylinder.

Marine Silicone Sealant is applied sparingly to the lower threads of the cylinder and upper threads of the foot valve. The parts of the foot valve are screwed together tightly with the aid of wrench spanners. The cylinder and foot valve are then tested for leakage by filling the cylinder with water. There should be no leaks.

The cylinder is then screwed into the lower coupling of the lowest PVC pipe. Care is required with this join to ensure it is leak free. Once again Marine Silicone Sealant is used at the joint. The rising main ropes are bound around the lower part of the cylinder and held tight with an extra rope. The ropes (two) should be long enough to reach the pump head, as the rope will be used to assist lowering and raising of the rising main and its components. A description of this cylinder and foot valve form part of the Bush Pump National and International Specifications.
Rods and rod connectors

Both 12mm stainless steel and 16mm mild steel rods have been studied. The 16mm rods proved superior, as the 12mm rods tended to flex in use and the thread length was much shorter and weaker than the 16mm threads. The 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 this method has been chosen as the ideal rod for this purpose in Zimbabwe. Although the 16mm mild steel rods are heavy they provide a smooth action during pumping which the 12mm stainless steel rods did not provide, possibly because 12mm rods are more flexible. Also the 12mm threads are smaller and of reduced length and strength compared to 16mm rods. The 3m lengths of 16mm rods are linked through 65/66mm long steel connectors. The method using the connector has been modified to 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.

Connecting the 16mm rods (as described above). The joints before treating with red oxide. This method has been on trial for some months and appears to be effective. To avoid rubbing of the steel rod on the plastic rising main a rubber or plastic guide should be fitted to each length of rod.

Red oxide coated rods and rod connectors used in this installation. This method avoids the use of lock nuts on exposed threaded rods, which can lead to rusting and erosion of the rod and loosening of the nut. In trials the thread held within the two tightened connectors did not rust when used on a well with aggressive water. During installation the rods are held and secured with a rod holding tool.
The piston used in this trial is a locally made unit similar to the India Mk II/III unit, but designed to accept a 16mm threaded rod. Nitrile rubber seals can be used, but need to be of the highest quality. The same holds true for leather seals. Both types of seal are on trial. Leather seals provide a smoother action and are preferred, but they must of the highest quality. Leather seals, being more flexible may open up in joints in the rising main. For this reason the pipe ends and internal surfaces of the couplings must be chamfered so the piston and seals passes smoothly through the joint.

This type of piston consists of a number of components which are screwed together. The photos below show the components which may vary slightly depending on the model. Suitable tools are required to separate the components. A screw driver can be placed through the upper cage to hold it secure. A spanner is required for the unit with a hexagon nut at the base. A screwdriver (as example) are required to turn the lower unit, so the parts can be separated and then tightened up again, once new seals are fitted. Special spanners can also be used to take the piston apart and then re-assemble it. A mono-block piston has also been tested but currently the unit described here is being used.

The complete brass piston with two seals made of high quality nitrile rubber or leather. Parts of the 63.5mm piston valve. The parts of the piston separated. Two different lower brass components are shown here, one with a hexagon, another with two opposing “pins” for tool attachment.

Assembling the piston and seals. The parts are cleaned and assembled in order, with the two new high quality 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. The parts should be done up tightly so they do not separate during use. These photos show a piston unit connected to a 16mm mild steel rod. Special spanners can also be used to tighten the piston together.

The piston used in current trials
Assembling the rod and pipe components on the ground

Fitting the “down the hole” components takes place in two stages. First introducing the foot valve, cylinder and PVC rising main. These are cut and assembled on the ground first to ensure they are well prepared for insertion. At the same time a matching set of 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 cylinder.

Assembling pipes and rods on the ground

Once the length of the rising main has 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 water discharge unit, floating washer housing, U brackets and upper rod together with additions rods and the PVC pipes and cylinder are laid on the ground. The pump head components at the upper end and the foot valve at the lower end. A minimum distance of 0.5m is left between the foot valve and the base of the well. The rods in this case have been cut to suit the well – matching the pipes now follows.

The uppermost pipe

The uppermost pipe in this case has a full length of 6m. One end is belled to form a socket into which other pipes can be solvent cemented. The other end is trimmed with a saw close to the end to make it square. Next a 700mm length is cut off with the belled end attached. This can come from the 6m pipe or from another pipe. This extra 700mm length is then solvent cemented on to the upper end of the 6m length of pipe. The reason for this is that the PVC pipe must be supported by an expanded section of the pipe on a pipe support plate (one of the tools required – see later) whilst the water discharge unit of the pump head is fitted.

A 700mm length of pipe (with a belled end) is cut off the pipe to be refitted at the top end. This expanded section will be supported on a pipe support tool during installation whilst the components of the pump head are fitted.
Chamfering the pipes and couplings

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 squared end held within the coupling must be chamfered, so that the piston seal meets no squared ends on its way up the pipe on removal.

The chamfering of the internal pipe edge within the coupling is performed with a sharp knife. A file is used to chamfer the internal wall of the pipe. All the pipes and couplings are chamfered in this way.

Solvent cementing the couplings to the pipes

Solvent cement is applied to the internal wall of the coupling and the outer wall of the PVC pipe and the two are joined with a twist. This operation must be performed with speed as the solvent evaporates rapidly.

Assembling the down the hole components

The steel barrel nipple can then be tested for a good fit into the threaded end of the coupling. In the case of the uppermost coupling it was decided to first fit the barrel nipple to the water discharge unit.
Couplings have now been cemented to the upper PVC pipe and a barrel nipple inserted into the lower coupling. Now the lower pipe (2 PVC pipes have been used in this installation) must be cut to the correct length and couplings cemented to each end. The pipe length is determined by placing all the rods in line (as if inserted in the pipe). The position of the cylinder is set so that the piston is 50mm above the place in the cylinder where the cylinder diameter is reduced. When piston and cylinder are set in place the cutting point of the lower pipe is determined. The threads of the upper cylinder will be wound into the lower coupling of the lower pipe. The lower pipe is cut in the appropriate position and the couplings cemented to each end. Marine Silicone Sealant is used to seal all the threaded couplings throughout the rising main and cylinder/foot valve system.

In this case the lengths of the pipes and rods have been tested on the ground first. This will not always be the case. On boreholes the pipes are placed down first to the appropriate depth, then the rods are added later, being cut at the pump head to the appropriate length. The best sealant for threads is Marine Silicone Sealant. In these early trials steel barrel nipples have been used and painted with red oxide. The barrel nipples should be made of brass, stainless steel or high strength plastic material. A wrench spanner is used to tighten (but not over tighten) threaded joints.

Use of Marine Silicone Sealant
This material is available in tubes for about US$3.50 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 clear Silicone Sealant
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. The first length of rising main will include the cylinder and foot valve with supporting ropes attached. The rope is useful as it can be used to both lower and lift the 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 lowest pipe segment with cylinder, foot valve and support ropes attached. These are stood upright on the rising main support plate of the pump head. Note the opened and shaped dip plug hole, through which the supporting ropes will pass.

This photo shows the important pipe support tool (made by John Norman). Half of the original unit is used. This tool fits inside the 100mm diameter opening of the rising main support plate. The rising main pipe can slide through this plate until an expansion of the pipe is reached. These will include the couplings. The plate will then hold up the pipe securely which other pipes are added to the rising main. The expanded section of rising main 700mm from the top of the pipe will hold up the pipe against the tool whilst the water discharge unit is fitted. The photo on the right shows the cylinder passing through the pipe supporting tool with the rope passing through the dip plug hole.
To allow the expanded sections of the rising main to pass the pipe holding tool, the tool must be pulled out and back. The rope can hold the pipe in place and assist in lowering and raising the pipe.

The lowest pipes is now held and secured in place by the pipe holding tool. The coupling exposes an internal thread reading for the next pipe. The upper pipe being carried to the pump site. The pipe is just over 6m long with the standard length plus to 700mm extension.

The upper pipe arrives at the pump site. The low weight of the PVC pipe allows for much longer lengths to be fitted at a time. 1m of 75mm PVC class 12 weighs 0.83kg. 1m of 65mm GI pipe weighs 6.84 kg. There is also a huge difference in the cost of the two materials. For shallower depths and for aggressive waters, the PVC may be a favourable option to consider. Thick walled Class 16 PVC pipe is best.
The upper pipe is attached to the lower pipe through the steel barrel nipple. The pipes are turned by hand. It is important to keep the upper pipe completely vertical to avoid cross threading of the plastic thread. The joint is done up tight by hand. In all cases Marine Silicone Sealant Pipe is applied sparingly to the threaded joint.

Using the ropes the upper pipe is lowered down the well to the point where the expanded joint 700mm below the top of the pipe is fitted. This joint will hold up the pipe whilst the water discharge unit is fitted.

The steel barrel nipple is already screwed into the water discharge unit of the pump head. This is now carefully threaded into the coupling bonded to the uppermost PVC pipe. Marine Silicone Sealant is used to seal the threaded joints. The preferred method is to attach the barrel nipple to the PVC pipe assembly first and then attach the barrel nipple to the water discharge assembly.
The final length of pipe is lowered down on the rope. Before it finally sits in position the rising main rope is tied up to another rope bound around the 65mm socket welded to the water discharge unit. This is simply to hold the rope in place and not to suspend the pipe. The pipe is finally lowered by hand. Note where the pipes are of greater weight further tools or manpower may be required to make this final movement.

**Lowering the pump rods**

The water discharge unit is now bolted to the pump head ready for insertion of piston and pump rods. As the rods are lowered by hand they are held in position at the joints with a rod holding tool, which has been in use for decades. This tool holds the rod connector in place whilst the rod above is attached and tightened.

The piston and rods are lowered down through the rising main. The rod connector at the top of each rod is held in place by the rod holding tool. The next rod is now threaded into the connector.
The upper rod and its connector is now lowered and threaded on to the connector of the lower rod. It is important that the upper rod is held in a vertical position to get an easy fitting. Once the two connectors meet they are made tight with an adjustable spanner – or preferably an open ended spanner. Thus the 2 rods are held tight by a single tightened point (like a car wheel nut or on pumps like the India Mk II). This type of fitting is still on trial with the Bush Pump. Existing trials reveal that water is excluded from the threads inside the connectors, thus greatly reducing corrosion. Once again Marine Silicone Sealant can be applied to this thread.

The lengths of rod are lowered and fitted together in the same way. Finally the top rod is fitted – this passes through the floating washer system and is connected by thread to the U bracket of the pump head.

The rods are now in place and the floating washer housing can be bolted together. The wooden head block is now fitted and the pump tested. Final the head bolts are fitted with their spring washers and nut which are held tight with the large pump spanner. The pump is now ready for use.
The rising main bailer

75mm PVC rising mains are light, unless they are filled with water. Then they become very heavy. Galvanised iron rising mains are much heavier. 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. 63mm PVC pipe is used to make the Bailer-bucket. The 63.5mm PVC pipe is fitted with a small brass non-return valve at the lower end (encased in a concrete plug) and a wire handle at the upper end. The bailer should be about 2m long. It is a simple and valuable tool. It simply lightens the weight of the rising main and makes it much easier to pull out by hand. If all else fails it can be used to extract water from the rising main and place it in a bucket!

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

The pump described here is on trial. Currently the PVC jointing, rods, links between PVC pipes and pump head and cylinder unit and the special tools are being monitored and where necessary improved. When a level of satisfaction has been reached at this preliminary stage then the testing can be extended to introducing prototypes into heavier duty and deeper sites in the field to further test the concept.
Ongoing investigations 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 in Zimbabwe or can easily be imported to Zimbabwe. The brass tube will originate in South Africa. The special nitrile rubber seals will also require importing from reliable sources. Specialised high strength PVC to thread connectors also require development.

I thank John Norman of Diesel and Plant for fabricating the first pipe coupling in HDPE, the pipe holding tool and various other components and also Gideon Matemazano, Managing Director of Prodorite for fabricating trial PVC couplings and providing test PVC pipe. I also am indebted to Oswald Chakauya for his most valuable assistance 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. This work, so far, is entirely privately undertaken. The intention is develop the pump further, so it becomes simpler 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. Only time will tell.

**Trials at Epworth using the PVC pipe rising main. The aim of the work is to make routine maintenance of the Zimbabwe Bush Pump (seal replacement and pipe lifting) a simpler operation.**

Further reading from Aquamor.info website

*The Bush Pump. 50mm open top cylinder model with 63mm PVC rising main. Aquamor. April.2016*

A large number of written works on the Bush Pump can also be found on the Aquamor website www.aquamor.info