Handpumps

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Handpumps

LOW COST WATER SUPPLY Series

This series of publications highlights sustainable methods of providing water supply to the rural areas of developing countries, notably in Africa.

When complete, the series will consist of four volumes:

Volume 1 - Well Siting
Volume 2 - Dug Wells
Volume 3 - Hand Drilled Wells
Volume 4 - Handpumps

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Your comments and proposals for improvement will be highly appreciated. Please send these to the address mentioned above, to be taken into account for a following edition.

> *All peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs.*
>
> Resolution on Community Water Supply
> United Nations Water Conference 1977

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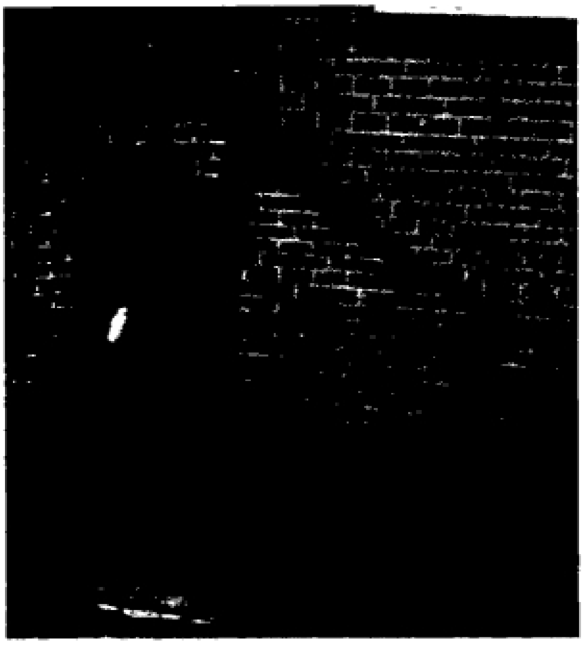
WHY HANDPUMPS ?

Then

As recently as a fifty to hundred years ago, most of the population of the western countries fetched their water from wells with buckets or handpumps. In those days many a farm or country house had its own handpump - outside in the courtyard, or in the kitchen, next to the kitchen sink. With the onset of piped water supply as we know it today, starting around the turn of the century, these individual water supplies increasingly gave way to the convenience of piped water, supplied in one's home by a (semi-) commercially operating water enterprise, and paid for in full by the consumer.



Typical individual farm handpump: well suited for individual families, but never intended for entire communities

Most of the handpumps used until that time were owned by individuals. The individual owner took good care of his pump, particularly when it was the only reliable source of water. The average handpump thus catered for less than 10 people, the only exception being the village pump, accessible to all, but generally used by the thirsty traveller only.

Now

In many developing countries, the water supply and sanitation situation at the middle of this century was alarming, especially in the rural areas. This led to the adoption of the Resolution on Community Water Supply (see back of title page) at the United Nations Water Conference of 1977, followed by the adoption of the *Water and Sanitation for All* target at the Alma Ata conference of 1978, and finally by the creation of the International Drinking Water Supply and Sanitation Decade (1981-1990) by the United Nations.

Already in the late sixties and early seventies, several donor organizations realized the importance of improved water supply and embarked on ambitious water supply programmes in developing countries in Africa and Asia. With hindsight we can now say that these programmes, often focusing on traditional (piped supply) technologies, more often than not became costly failures. They did not reach their intended goal of supplying the vast rural population with water, as the economics of (rural) water supply were generally neglected: the beneficiary population not being able to pay the actual cost of water, with their Governments generally not having the financial means to do so either, with a neglected infrastructure which was not able to sustain public water supply efforts.

Slowly the realization dawned that piped water supply, though being convenient to all, is only within the reach of a privileged few in the cities. From the mid-seventies onwards attention thus shifted - sometimes grudgingly - to individual water sources (also called *point sources*) that could be maintained by an individual or a local community only· open, dug wells and boreholes fitted with handpumps. At the same time, spurred by the demonstrated failure of traditional technologies in many developing countries, *Appropriate Technology* became a popular, though often misunderstood and misapplied, concept. Often erroneously interpreted as simple, home-made technology (or, even worse: the re-introduction of old western technology, such as the farm handpump, but in a vastly different situation), it is better defined as ***technology that is best suited to solve the problem at hand***

under existing physical and cultural conditions and at the lowest initial and operating cost. As such - depending on the local situation - appropriate technology may involve the application of the most modern materials and designs, using state-of-the-art technology.

Types of individual water sources

Point sources for water supply - as well as pumping devices - can be distinguished according to:

- the type of construction: open or closed/covered wells or boreholes
- the depth to the water table: shallow versus medium depth or deep wells or boreholes

Everybody's property is nobody's property! The well will be out of use within a few years.

Privately owned, the well may last for more than a century.

Open wells are the earliest types of point sources created by man. With gourds, leather bags or buckets as water containers, and ropes or winches used for pulling them up, these wells have been in use since times immemorial, for drinking water, cattle watering and irrigation water supply.

In ancient civilizations large open wells were used even to fill elaborate pond and fountain systems, the water drawn up in buckets or leather bags by spans of bullocks led down special ramps.

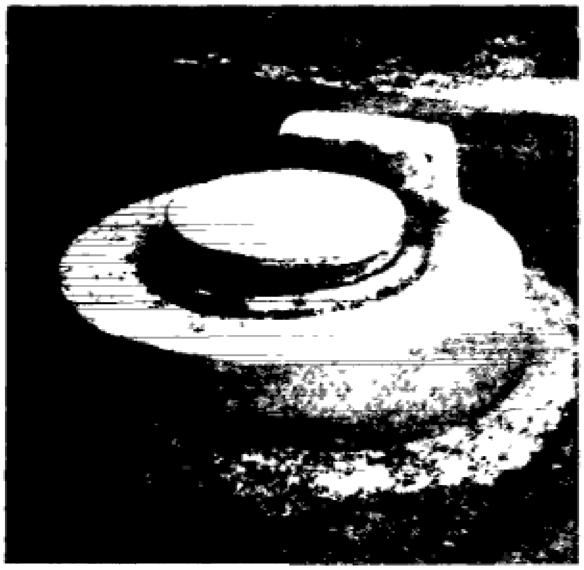
Open wells can be constructed only by skilled persons (see *Volume 2: Dug Wells*), and are, therefore, relatively expensive to construct. In addition to being vulnerable to damage by buckets scraping against the well walls, their major drawback is their susceptibility to contamination:

- bird droppings,
- leaves,
- deliberate human contamination,
- small animals drowning in the well, etc.

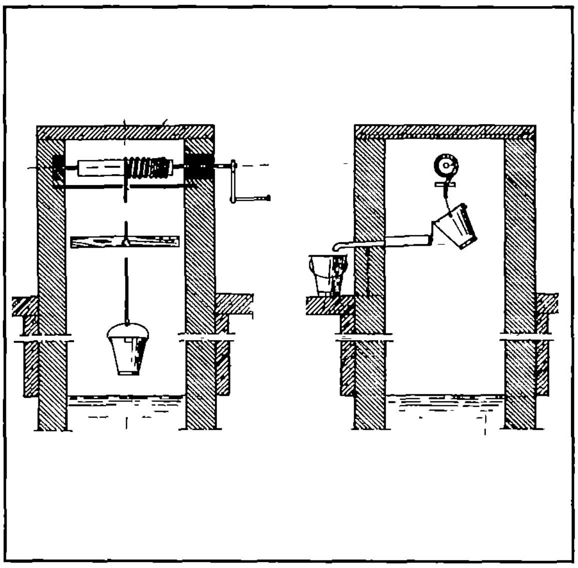
Another, less obvious, one is dirt from the soil that gets stuck to the underside of the bucket when it is put down on the ground near the well, in between use. Especially if the well is used also for cattle watering, cattle droppings may have become mixed with the soil around the well, thus causing bacteriological (faecal) contamination and rendering the water unsuitable for human consumption. Similar problems were experienced with large, so-called *step wells,* where users contracted guinea worm by standing in contaminated water.

To prevent pollution, wells have thus sometimes been covered (against bird droppings) and raised above ground level (children or small animals can no longer fall into them), while more elaborate constructions were devised for preventing the bucket or bag from becoming contaminated.

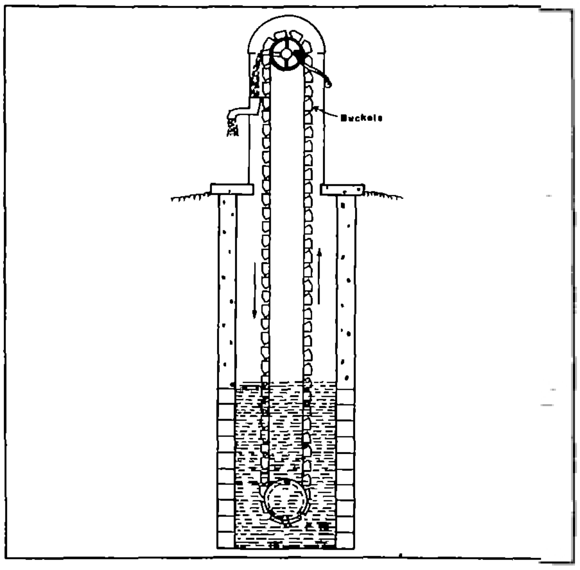
Several of these, including chains of buckets, or self-tipping buckets within a - often wooden - closed structure, are illustrated below. The most sophisticated option, the use of a motor pump suspended in a fully covered well (e.g. electrical submersible pumps, diesel-driven turbine pumps, etc.), is less suitable for use in the rural areas of developing countries, as it requires the availability of electricity, diesel oil or solar power, expensive - often imported - pumps and spare parts, and skilled labour for operation, maintenance and repair.



Covered open well



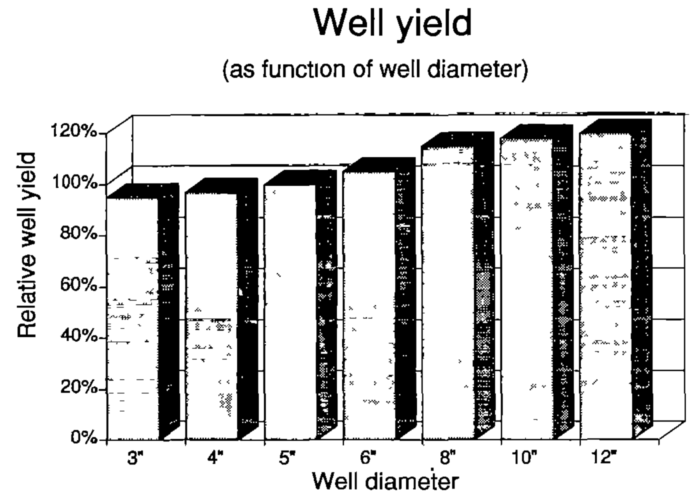
Well with self-tipping bucket



Bucket pump

The better solution: covered well with handpump

The size of the water source to a large extent determines which water abstraction device can be used. open wells, with their larger diameter, allow the use of buckets or bags, but these can obviously not be used in smaller-diameter boreholes. With (shallow) boreholes gaining in popularity, not only because they are - by definition - covered, but also because small-diameter wells are generally more cost-effective than wells with large diameters (see *Volume 2: Dug Wells* and diagram below), handpumps have thus become the most widespread means of groundwater abstraction.



Limited effect of enlarging well diameter on well yield; yield of 3" well taken as 100%
Wells with a 4 x larger diameter (and 16 times larger cross section) only yield about 20% more water!

The depth to the groundwater table is another, important criterion, which often determines what type of pumping device may be used:

- a deeper water table requires more effort for lifting water, thus leading to the use of a pumping device with some kind of mechanical advantage (e.g. lever-type handpumps), or diesel or electrically operated pumps;
- beyond about 7 metres of depth to the water table, the use of the simplest type of handpump (with a surface-mounted cylinder/plunger) is no longer possible, as the atmospheric pressure limits the suction head under field conditions to about 7 m. In such cases a handpump with submerged cylinder is to be preferred.

Therefore:

☐ for **shallow aquifers** (less than about 7 m deep):
  - suction pumps may be used (though with certain disadvantages, as described later)
  - lift pumps with larger-diameter cylinder may be used, the larger pumping effort caused by the larger-size cylinder being compensated by the lower lift.

☐ for **deeper aquifers**:
  - use lift pumps with smaller-diameter cylinder, thereby reducing the pumping effort required (feasible till at least some 60 m depth);
  - for deeper wells or larger cylinders: use pumps powered by diesel engine or electrical motor.

☐ for **public use**, do *not* provide facilities that:
  - are of a complicated nature
  - are vulnerable
  - survive only when maintained in a spic-and-span condition; such facilities are suitable for **private use** (and maintenance) only.

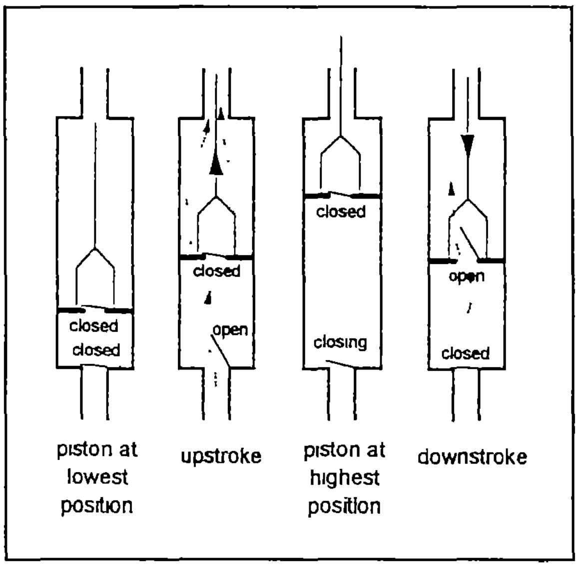
☐ for **community use** only provide facilities that are:
  - strong and sturdy
  - apparently over-dimensioned
  - virtually maintenance-free.

Types of handpumps

Reciprocating (plunger) pumps: the plunger (or piston) moves up-and-down in the cylinder:

- On the upstroke, the plunger pushes water into the rising main and replacement water is drawn into the cylinder through the foot valve by suction (atmospheric pressure).
- On the downstroke, the foot valve closes, a valve in the plunger opens, and water passes through, to be lifted on the next upstroke.

During the upstroke, the volume of water pumped is - at least theoretically - equal to a water volume above the piston that has a height which is equal to the stroke length. In practice the efficiency is less than 100%, due to secondary losses in the valves, friction, etc.



Operation of reciprocating pump during up- and downstroke

During the downstroke, the volume of water passing through the valve in the plunger equals the volume under the piston that - again - has a height that is equal to the stroke length. The space simultaneously becoming available above the piston has the same height (equal to the stroke length), but the net volume is less than under the piston, as a part is taken up by the pump rod. Therefore, also during the downstroke some water is pumped upward, viz. the volume taken in by a piece of pump rod with a length equal to the pump stroke.

Therefore, depending on the ratio between the diameter of the pump rod and the diameter of the cylinder, the pump may be:

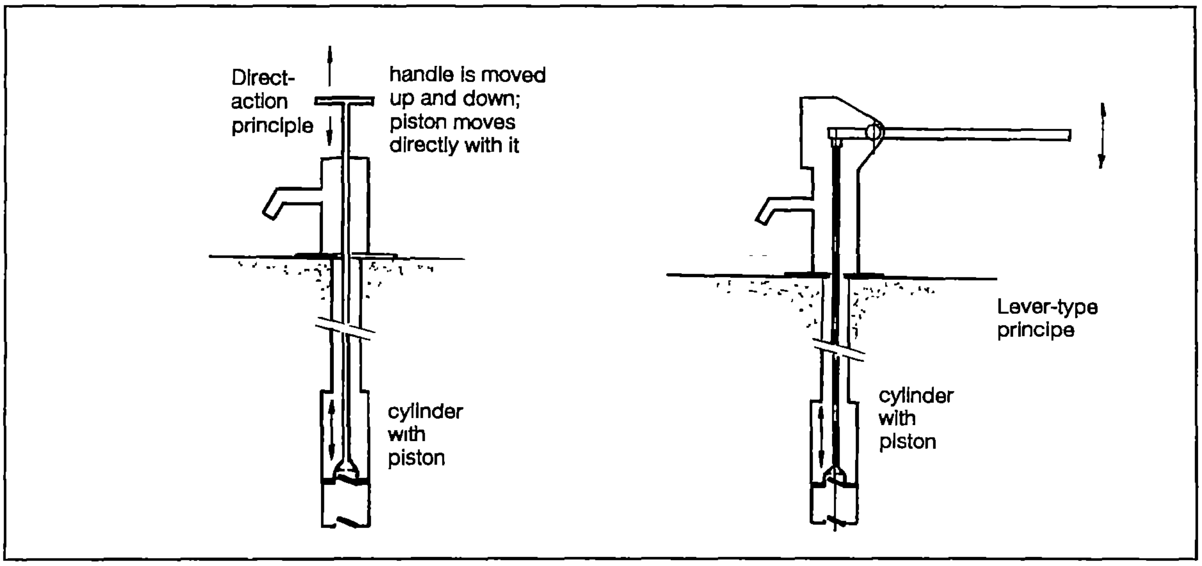
- *single acting:* main pumping action is on the upstroke; negligible pumping action on the downstroke (relatively thin pump rod);
- *double acting:* clear pumping action during upstroke as well as downstroke (relatively thick pump rod). The smoothest action is obtained by such dimensions of pump rod and cylinder that equal volumes are pumped during upstroke and downstroke.

There are various ways to achieve the up- and downwards action of the piston. These are generally classed in two categories:

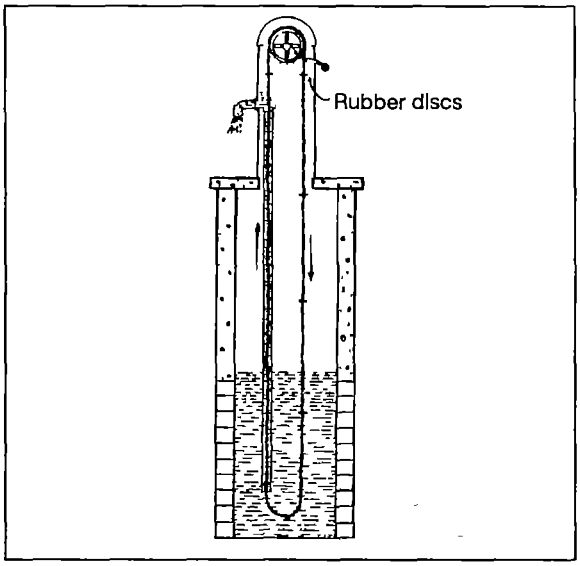
- direct action pumps, whereby the user directly moves the pump rod up-and-down. Examples are the hand-operated AFYA and the NIRA AF85 direct action pumps;
- pumps where a mechanical advantage is used, e.g. by operating a handle or lever (the most common type of handpump) or a flywheel Examples are the various SWN handpumps (SWN 80, SWN 81, SWN 90), India Mark II/III handpumps, Duba handpump, etc.

Hand-operated **Rotary (positive displacement) pumps** are much less widespread. Two main types can be mentioned:

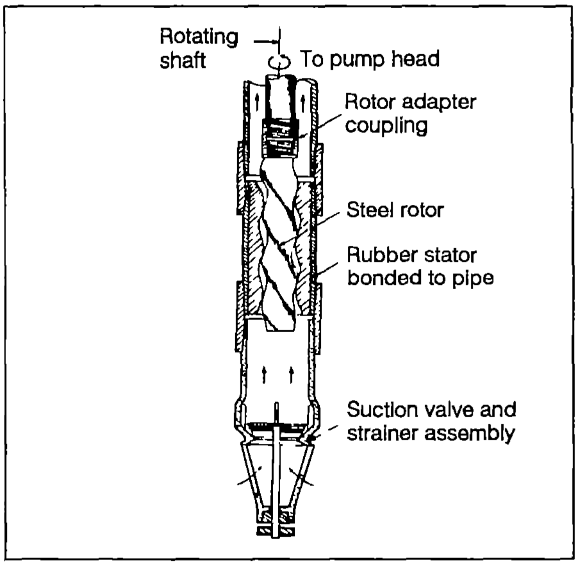
- *chain, rope or bucket pumps*:
    - the *bucket pump* consists of a chain of (small) buckets running over sprockets. Each bucket dips into the water at the bottom and discharges into a spout at the top;
    - a simpler variety is the *chain or rope pump*, whereby discs or knots at fixed intervals lift the water through a tight fitting pipe
    - *helical rotor pumps*: a helical rotor turns inside a helical sleeve or stator and lifts the water by positive displacement.



Direct action versus lever-type handpump



Chain or rope-and-washer pump

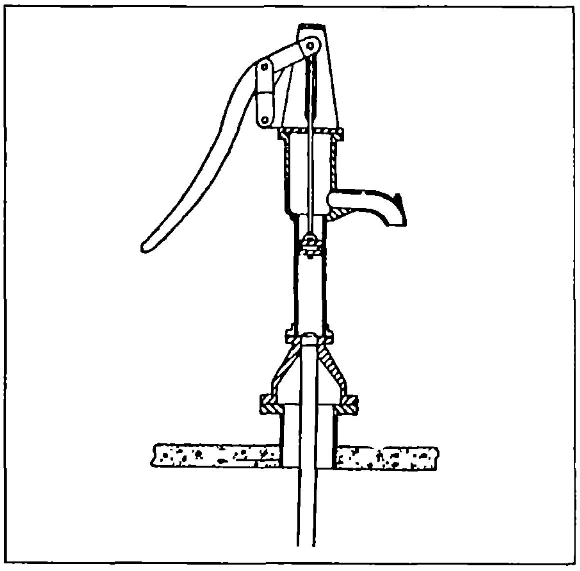


Helical pump

Type of pump	Usual depth range	Characteristics
Reciprocating or plunger pump:		Low operating speed, hand, wind or motor powered, with or without a flywheel.
• suction pump • lift pump	• up to 7 m • virtually unlimited	• Usually requires priming. • No priming necessary.
Rotary handpump:		Low operating speed; hand, wind or motor powered.
• chain and bucket pump • helical rotor pump	• up to about 10 m • up to about 75 m	• Limited output. • Expensive spare parts.

How to select a handpump type

Which type of handpump (or size of cylinder) to select, depends on two things:



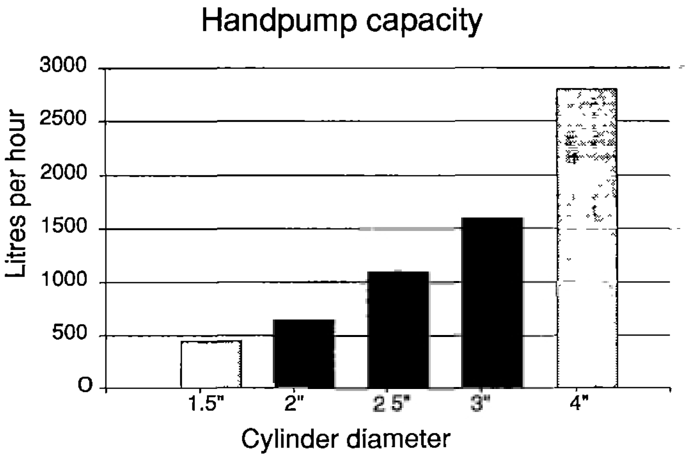
Suction pump

- ☐ What is the depth to the groundwater table?
    - if this depth is not greater than about 7 m, it is possible to use a *suction pump*, in which the piston is located in the pump body itself, and not under water. The atmospheric pressure pushes the water into the vacuum created by lifting the piston. This explains why the piston may not be more than 7 m above the water table (theoretically 10 m, equivalent to 1 bar pressure, but in practice less, due to various losses);
    - for depths down to about 10 metres, a direct action pump can be used (for the common sizes of pump cylinders);
    - for a given handpump, the effort that is required to pump water, increases with the square of the cylinder diameter times the lift that is required. It is, therefore, possible to use larger-diameter cylinders at shallower water depths.
- ☐ What is the required output of the handpump?
    - for human consumption the normal use of water from handpumps is in the order of 20 - 40 litres per head and per day. With numbers of people per handpump up to 250 (the maximum number often adopted in large-scale donor-assisted handpump programmes), but as an average being closer to 125 as field experience indicates, the required cylinder diameter is as shown in the table (assuming 40 strokes per minute, of 15 cm each):

	Number of users per handpump:	
	125	250
OPTION:	Theoretically required cylinder diameter:	
Minimum option: 12 hours pumping per day; 20 litres/day per person	27 mm (1.06")	38 mm (1.5")
Maximum option: 8 hours pumping per day; 40 litres/day per person	47 mm (1.85")	66 mm (2.6")

Which assumption is the more realistic, depends on various circumstances. Experience in several large-scale handpump projects has shown that the average number of people using a single handpump, even in densely populated rural areas, is seldom more than 125, even though in urban fringe areas around 250 persons may indeed be using one handpump. Field investigations in East-Africa showed per capita consumption to be well below 20 litres/day and often even below 10 litres/day. Consequently, the "minimum option" indicated in the table may be the more realistic one, indicating that a cylinder diameter of about 40 mm (1 5") would theoretically be sufficient. Allowing for a certain percentage of handpumps to be out of order, a slightly larger cylinder size (50 - 75 mm, or: 2" - 2½") would be in order.

- for small-scale irrigation or other commercial use of water, as well as for filling roof tanks of small institutions (schools, clinics, dormitories), larger outputs are generally required, which necessitate the use of larger-diameter pump cylinders (e.g. Ø 100 mm and more). Depending on the water depth, such pumping might be extremely tiring, as it should be done for a considerable number of hours per day[1]. Such an application of handpumps is therefore generally not feasible. Supplying a small and well-designed irrigation system (e.g. *drip irrigation*) from a handpump would be entirely feasible, however, as a cylinder diameter of about 50 - 75 mm (2 - 2½") would be sufficient.



Handpump capacity as function of cylinder size; 40 strokes per minute

In practice, the considerations of water depth and required output are often interlinked: a high output (thus: larger cylinder diameter) may be desirable, but its use may not be practical in view of the water depth, as it might require too much effort in pumping. A shallow water table, on the other hand, might allow the use of larger-than-necessary pump cylinders, thereby offering the benefit of additional water which might be used for keeping a small vegetable garden. In practice, application of handpumps is limited to cylinder diameters in the range 2 - 3": at smaller diameters the pump efficiency drops too much, whereas larger cylinder sizes require too much effort.

The *suction pump* mentioned on the previous page has various advantages: it is simple compared to a lift pump, as it can be mounted directly on the rising main of the well. It is therefore used often on rammed or jetted wells (see *Volume 2: Dug Wells* and *Volume 3: Hand Drilled Wells*), offering a low-cost solution. It has two serious disadvantages, however:

- because of the limitations to the water depth, it can normally be used only on the uppermost water bearing layer, which is easily polluted, or at least not bacteriologically reliable. In many cases this aquifer is also used for small-scale irrigation, which more often than not implies overpumping and falling water tables. Consequently, there is an increased risk of such pumps falling dry;
- the operation of the pump relies on a vacuum being created below the piston, as a result of which the atmospheric pressure pushes the water up against the piston. In case the foot valve is leaking and the piston no longer fits tightly into the cylinder - as often happens when leather cup seals are used and the pump is allowed to stand idle for some time - water drains from the pump. This then stops functioning, and needs to be *primed* to render it operational again. If water is not readily available - often the reason why the pump was installed in the first place - any conceivable fluid may be used for priming, with all possible consequences.

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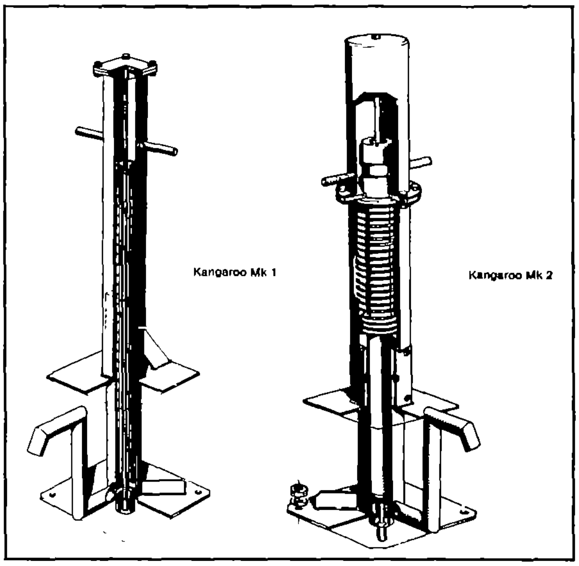
[1] An average male can provide about 0.05 HP during a short period of time. Assuming an over-all pump efficiency of 50 %, this means that he can pump not more than about 0.7 m^3 per hour from a depth of 10 meters, and then for a short period only.

For these reasons, suction pumps are not recommended for drinking water supply, and lift pumps, where the cylinder is located below the lowest expected groundwater level, are to be preferred.

History of SWN[2] pump range

☐ **Kangaroo pump**: One of the main lessons that can be learned from any handpump project is that maintenance aspects are crucial for a successful handpump design. In Tanzania especially hinge and pivot points proved to require frequent maintenance (greasing, replacement of bearings, etc.). Consequently, during the seventies the Kangaroo pump was developed, a foot-operated direct-action pump without any hinge or pivot point. The pump head was directly connected to the cylinder through the pump rod, and pushed down by stepping on the footplate; the pump head would move upwards again under the influence of a coiled steel spring.

Although being a reliable pump with a high potential output, for instance for small-scale irrigation (it is easier to provide energy with one's legs than one's arms) the pump proved to be relatively expensive, while difficult to maintain in corrosive environments (stainless steel springs are not available; neither is a reliable and flexible anti-corrosion coating with which the spring could have been protected). In addition, adapting the pump to different water depths was complicated: unless springs of different strengths would be used — which would complicate maintenance considerably — the only manner of adapting the pump unit was to vary the cylinder diameter. Under certain circumstances the pump was therefore difficult to use by small children.



Kangaroo foot-operated direct action pump

For shallow water tables a simple pump was later developed the *Afya direct action pump*. The main objective of this pump type was to provide a very low-cost alternative for water depths up to 10 m.

☐ **SWN 80 handle pump:** Once reliable alternatives for ball and roller bearings became available, one of the main obstacles to designing maintenance-free handle pumps could be removed. Hence the SWN 80 pump was developed, in the early eighties. In addition to a standard pump stand (as described in the following paragraphs) this pump featured a hot-dip galvanized steel pump head with journal bearings that allowed replacement by ball bearings of a standard commercial size, if required. The pump is suitable for water depths to about 40 m.

☐ **SWN 81 handle pump:** For larger water depths (up to about 80 metres) a heavier and larger-size pump head was developed, the SWN 81 pump head. This also featured a handle with a counterweight that could be adapted to the individual well's water depth. This pump head was again provided with (heavy-duty) journal bearings, allowing replacement by standard-size ball or roller bearings. In practice, however, such replacement was hardly ever carried out.

A further improvement of the pump head bearings then resulted in the:

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[2] SWN = Sociale Werkplaats Nunspeet, a sheltered workshop for the handicapped, which has participated in the development of the SWN family of handpumps from 1976 onwards.

- **SWN 90 handle pump:** This pump replaces the SWN 80 handle pumps and SWN 81 pumps for water tables up to about 60 metres. For these depths the standard high-impact PVC riser pipes can still be used, and the improved (full width) journal bearings of the SWN 90 pump head can easily absorb the resulting loads. Only for depths of more than 60 m the SWN 81 pump is required: at these depths the stretch and creep of PVC riser pipes result in an unacceptable reduction in pump performance, so that the use of GI riser pipes becomes necessary, together with the heavier SWN 81 pump head.

  For the vast majority of handpump applications, however, the SWN 90 pump head is not only superior to the SWN 80 and 81 handpumps, but also cheaper to manufacture, and has thus become the standard SWN handpump. Altogether, handpumps from the SWN range have been tested, used and manufactured in developing countries for nearly 20 years!

Recommended handpump types

The following handpump types are recommended:

- **2 - 10 m deep water table:** *Afya direct action pump*

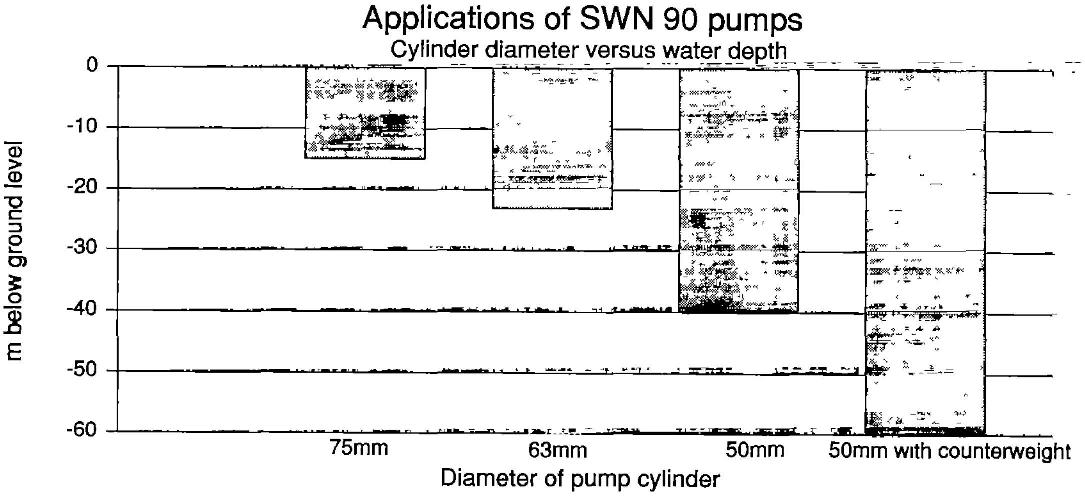
With a Ø 60/52 mm (2") cylinder this pump can yield between 500 and 600 litres per hour, sufficient for most domestic water supply purposes. It can, moreover, be installed inside a Ø 75/69 mm filter pipe. This means that a well suitable for an *Afya* direct action pump can be drilled with a Ø 150 mm hand drilling set, which can easily be transported in a pickup or larger saloon car.

- **10 - 60 m deep water table:** *SWN 90 pump:*

Depending on the depth, cylinder sizes Ø 75 mm (3"), 63 mm (2½") and Ø 50 mm (2") are the most logical choice (pump yields of 1 to 1.5 cubic metres per hour). For shallower wells these pumps may drive the larger cylinders, e.g. for cultivating a vegetable garden: Ø 75 mm (3") cylinder yielding around 1.5 m^3 per hour. For special cases also larger-diameter cylinders can be supplied, e.g. Ø 100 mm (4").

- **60 - 80 m deep water table:** *SWN 81 pump:*

In principle the same cylinders can be used as with the SWN 80 pump, but the pumping effort increases with greater depth. Therefore best suited for Ø 40-50 (1½-2") cylinders. It is possible to increase the weight of the handle through counterweights, thus facilitating pumping at greater depths, as illustrated below.



Handpump design philosophy

Several different schools of thought exist on the most desirable handpump design. These range from the extreme of the ***handpump that continuously breaks down*** ("people become thoroughly familiar with maintenance and repair because they have to do it continuously") to the ***maintenance-free*** handpump ("a handpump requiring any maintenance during its lifetime is the product of imperfect engineering"). Which design philosophy is the more realistic one to be applied, depends on the local situation: an area where reasonably skilled artisans are readily available anywhere, and where spare parts for handpumps would be available at several places in each community, obviously asks for a different approach than one whereby the nearest mechanic is located hours away, and where spare parts have to be fetched from the regional or national capital. Another criterion is obviously the ability and willingness of the local population to pay for handpump maintenance and design.

The SWN range of pumps was developed for the rural African situation. Therefore, the design philosophy adopted is closest to that of the *maintenance-free handpump*: during its lifetime of about 10 years the handpump should remain operational even when installed on a less than perfectly vertical well or borehole, without regular maintenance and under heavy use.

In the early seventies the Shinyanga[3] Shallow Wells Project was one of the first large-scale rural water supply projects based on the supply of water through handpumps fitted on shallow wells, and many a lesson was learned from the behaviour of handpumps under those conditions. This resulted in apparent over-dimensioning of several critical handpump components.

Later on, a score of other donor-assisted rural water supply projects were started up in East-Africa, several of which used the same handpumps. This approach led to a certain *standardization* of pump components, whereby essential parts of SWN handpumps and those of other programmes were made *interchangeable*, thus improving the reliability of maintenance by allowing handpumps to be repaired with parts even from other handpump makes. This was later institutionalized at a donor conference at Morogoro, Tanzania, in 1980.

Handpump components that were standardized are:

- foot plate size: 400 x 400 mm x 8 mm thickness (thick enough to prevent bending/buckling of the foot plate and the resulting swinging of the riser pipe)
- M16 (or 5/8") anchor bolts (thinner bolts would theoretically be strong enough, but would not possess any margin against corrosion. The latter is required as the bolts may not be galvanized as that would prevent a good bond between bolts and concrete)
- anchor bolts (4 in total) at 330 mm on centre (the large distance is required to absorb the forces exerted by the pump handle; a square bolt pattern allows the pump to face any of four directions, unlike a rectangular setting which limits this to two directions)
- riser pipe with 1.5" standard BSP threaded connectors
- Ø 10 mm (stainless) steel pump rod with M10 threaded couplings

Both for these and the other parts the design is based as much as possible on the *maintenance-free* philosophy: heavy-duty parts, where necessary made of corrosion-free materials, in such a way that both the main structure and the various parts have the same expected lifetime. Hence the handpump should be able to last for about 10 years under typical local circumstances with little if any maintenance only.

The philosophy behind this standardization was:

- to allow for the exchange of worn or broken parts by similar parts from other handpumps, as identical connector sizes were used

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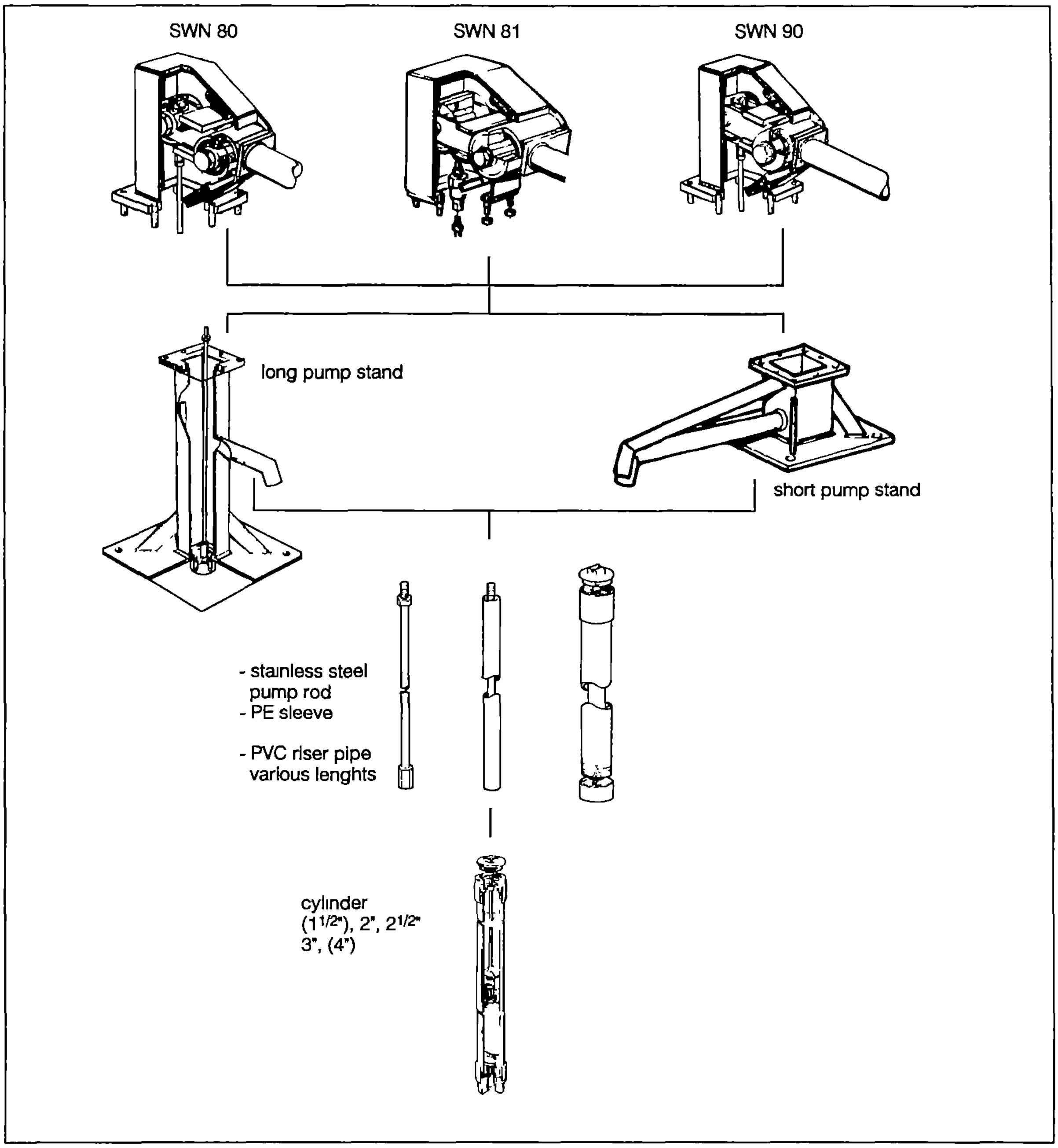
[3] Shinyanga is a region of Tanzania, 150 km south of Lake Victoria. Here one of the first large-scale shallow wells projects was started, in 1974, with Netherlands assistance.

- to allow replacement of the pump unit, e.g. after a useful lifetime of 10 years, by one of the same make or one of the other pumps included in the standardization programme.

The "family" of SWN handpumps is based on a modular design, with interchangeable parts as illustrated in the diagram below. The various parts are described in detail in the next chapter.



Overview of SWN pump range

DESCRIPTION OF SWN/AFYA PUMP PARTS

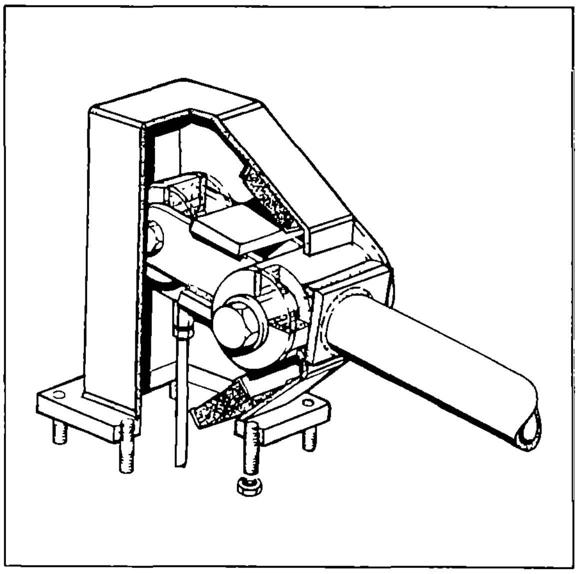
Pump components

In this chapter the following components are described in detail:

- pump head (with special mention of handle and bearings)
- pump stand
- riser pipe
- pump rod
- cylinder

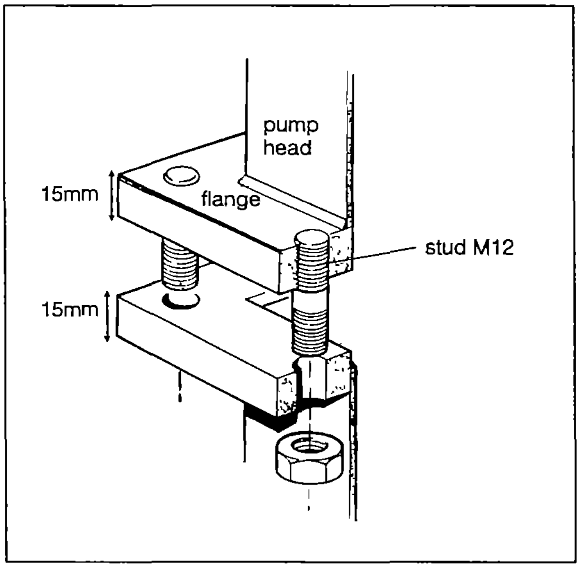
Pump head

With the exception of the *Afya* direct action pump head, all pump heads of the SWN series are interchangeable, sharing the flange dimensions of 160 x 160 mm, and having eight M12 threaded studs (spanner size 19) for the M12 galvanized nuts. The basic design of the pump heads is so as to minimize the number of loose parts, separate covers, or other parts that can or must be accessed from the outside, and can thus be lost or stolen.



Typical SWN 90 pump head

All pump heads are hot dip galvanized and made of plate steel, with 15 mm thick steel flanges. Field experience shows that most handpumps get out of order because of play in a connection somewhere. The thickness of the flanges was thus chosen especially to render them stiff enough to prevent any movement of the pump head relative to the pump stand being caused by operating the pump handle. In the same way the stiffness of the pump stand prevents the pump anchor bolts from working themselves loose, which can often be seen to be the start of pump failure for pumps with a different design.



Detail of flange connection

Studs are used rather than bolts for increased reliability: even with several nuts missing, the weight of the pump head, and the studs being an integrated part of the pump head, ensure that the head remains reasonably stable on the pump stand. By comparison, a pump head fixed with bolts and nuts would have become unusable under the same conditions.

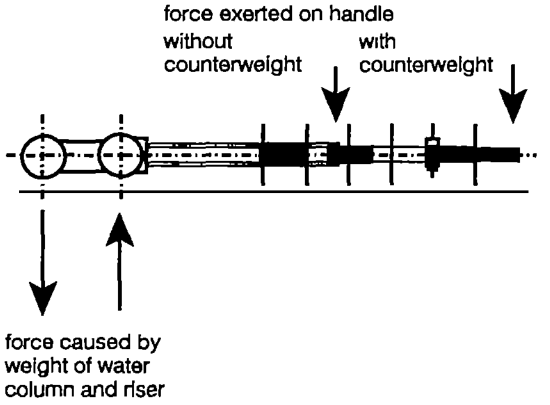
The typical characteristics of the SWN pump heads are as follows:

- SWN 80: standard pump head (100 mm wide) for medium deep wells (up to 40 m)
- SWN 90: same dimensions as SWN 80 pump head, but with heavier bearings, suitable for all but the deepest wells (up to 60 m)

- SWN 81: heavy-duty pump head of larger dimensions than SWN 80/90 (160 mm wide pump head); therefore suited for deepest wells (up to 80 m)

Pump handle

The standard SWN 90 pump handle is a hot-dip galvanized thick-walled 1½" pipe (Ø 48.3/35.7 mm) with a length of 0.90 m. Especially in combination with an SWN 90 or 81 pump head (designed for use on wells deeper than 40 - 60 metres) the pump handle can be provided with an extension part or counterweight for use on such deeper wells. Examples of the use of counterweights, as a function of well depth and cylinder diameter, are given in the following table. From that table it can be seen that counterweighing the handle is required for depths from about 30 - 40 m onward, for cylinders of 2" and larger diameter.



water level [m]	piston diameter [approx.]	counter-weight required ?	force required at tip of handle [kg]
10	3"	no	8
15	3"	no	12
25	2½"	no	15
40	2"	no	18
60	2"	yes	14

Influence of counterweight

The standard pump handle has a mechanical advantage of 131 mm : 900 mm, or about 1:7. A calculation on the basis of the actual weights of the handle components shows that the handle itself exerts a positive moment of about 1.5 kgm. This means that up to a water depth of about 6 m, there is a residual moment on the handle, which makes the tip of the handle move downwards.

For greater water depths the moment caused by the weight on the pump rod has the tip of the handle rise, as illustrated in the following examples:

- *water table at 10 m depth; Ø 75 mm (3") cylinder*
  The net load on the pump handle is caused by 10 - 6 = 4 m of pump rod, or: about 3.2 kg (dead weight); in addition the water column on top of the piston (surface area of 45 cm^2) causes a load of 45 kg. Assuming 10% friction the total load thus becomes 55 kg. With a mechanical advantage of about 1:7 this means that the force to be exerted on the handle must be 55/7 kg, or about 8 kg. This is well within the power of even a child.
- *water table at 15 m depth, Ø 75 mm (3") cylinder*
  The net load on the pump handle is caused by 15 - 6 = 9 m of pump rod, or: about 7.2 kg (dead weight), in addition the water column on top of the piston causes a load of 65 kg. Including 10% friction the total load thus becomes 80 kg. With a mechanical advantage of about 1:7 this means that the force to be exerted on the handle must be 80/7 kg, or about 12 kg. For children this is about the limit, meaning that **for practical purposes the application of a 3" cylinder is restricted to water depths of not more than 15 metres.**

- *water table at 25 m depth, Ø 63 mm (2½") cylinder*
  Using the same type of calculation, the force required to operate the handle is 15 kg, which is within the acceptable range.

- *water table at 40 m depth, Ø 50 mm (2") cylinder*
  Under these conditions, a force of 18 kg is required to operate the pump handle. This should be considered to be the practical limit. For deeper water tables a counterweight must thus be used.

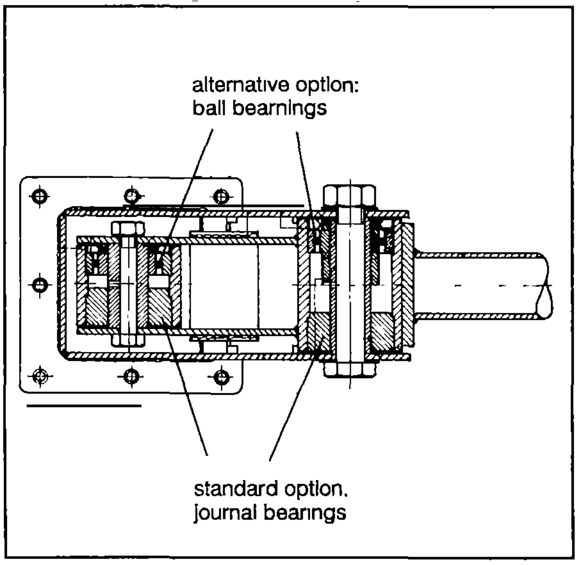
- *water table at 60 m, Ø 50 mm (2") cylinder, pump handle with counterweight*
  The weight of a solid steel bar Ø 35 mm, length 1 m, is 4 kg. If half of this bar is fitted inside the pump handle, with the other half protruding from it, it increases the mechanical advantage to 1:10.7 (total length of handle is now 0.90 m + 0.50 m = 1.40 m).

  The net load on the pump handle is caused by 60 - 6 = 54 m of pump rod, or: about 43.2 kg (dead weight); in addition the weight on top of the piston (surface area of 20 cm^2) causes a load of 120 kg. Including 10% friction the total load thus becomes 180 kg. With a mechanical advantage of 1:10.7 this means that the gross force to be exerted on the handle must be 180/10.7 kg, or about 17 kg. Adjusted for the moment exerted by the counterweight the net required force is about 14 kg, which is again within the acceptable range.

The examples given above illustrate that for a specific groundwater table condition one particular cylinder size is suited best. In case a project covers a larger number of wells not exceeding about 25 m in depth, it may be better, however, to limit the cylinder size to 63 mm (2½") — also for shallower wells — for reasons of standardization and simplifying spare parts supply.

Bearings

The SWN pump bearings are designed for a lifetime of 10 years or more. During the years several types of bearings have been tested, and the current set-up was selected as the most reliable one.

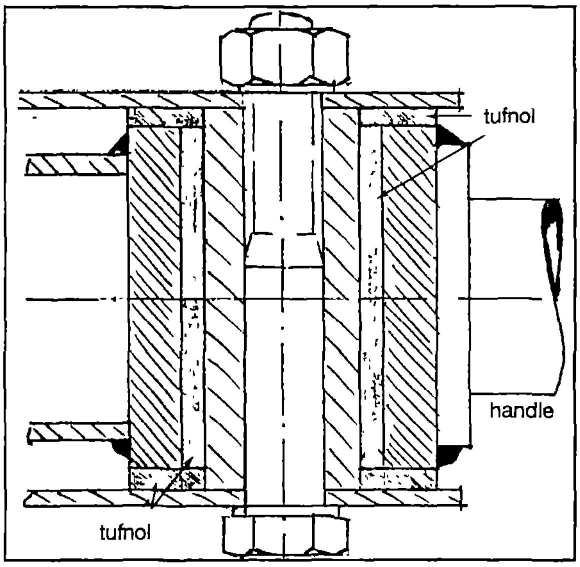


Ball bearings or journal bearings in SWN 80

- ☐ **Ball bearings**
  This type of bearings is the normal one used for rotary parts. They have the advantage that they are readily available in most parts of the world, including Africa. However, they need to be greased regularly, a condition that is not generally fulfilled in rural areas. So-called *life-greased bearings* have grease contained by thin covering plates. That design is suitable when the pump is in an exactly vertical position; if not, the covering plate is slowly eroded by the moving parts in the pump head, and rather than being greased, the bearing may be filled with dust or even sand. In addition, a handpump bearing is not rotating but rocking only, so that wear is concentrated on a single or a few bearing balls, resulting in faster wear of the bearing than was anticipated The rocking effect also acts like a windscreen wiper, pushing the lubricant away from the bottom ball. Also at slow speed the balls do not ride on top of the lubricant, but push through it. The load on a bearing must not be under-estimated either: assuming a maximum force on the pump handle of about 20 kg, and taking a (reduced) mechanical advantage of 1:5, the force exerted on the pump rod is 100 kg, implying a force on the main bearing of 120 kg. The habit of pumping with quick successive strokes of short length

furthermore introduces a shock coefficient which may easily be a factor 5, so that the force on the main bearing becomes about 600 kg. This force being exerted on a single, practically stationary, bearing ball (the situation that occurs when the pump is not 100% vertical) proved to be too much for even the best brands of roller bearings, even when mounted on a Ø 30 mm steel shaft (many other handpump types use thinner shafts, e.g. Ø 20 mm, which therefore results in even quicker failure of the ball bearing).

- ☐ **Thin-walled journal bearings**
  These have been promoted as being a solution suitable for rural Africa. Because of the low friction, no grease would be required. However, the material allows hardly any erosion at all because of its limited thickness. As was mentioned for 'life-greased' ball bearings, a slight misalignment of the well/handpump will result in asymmetric wear of the bearing. With a limited thickness of the bearing this means that the rotating parts will soon wear against the steel components of the pump head, which will quickly result in failure of the pump. This was borne out by field experience: pumps provided with this type of thin-walled journal bearings reportedly did not last longer than about 6 weeks!



Thick journal bearings in SWN 90 pump head

- ☐ **Thick journal bearings over pin**
  This concept combines the advantage attributed to the previous option: low friction material not requiring any greasing, with a sufficient thickness as well as special wearing disks. Consequently, this type of bearing is suitable also in case the handpump is out of true (as will generally be the case)

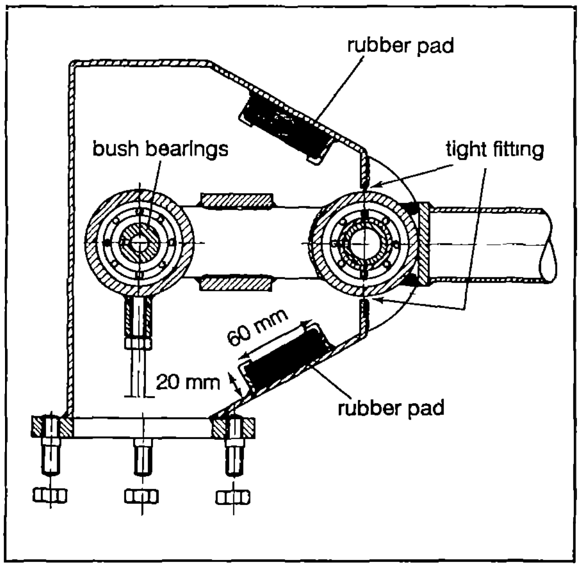
All SWN handpumps are provided with thick journal bearings ex-factory. For the SWN 80 and SWN 81 pump heads, these have such dimensions that replacement by commercially available ball bearings is possible, the difference between the two being that the SWN 81 pump head is larger (160 mm width, versus 100 mm for SWN 80/90).

In practice, however, the need to replace journal bearings by ball bearings has proven to be virtually non-existent. Therefore the SWN 90 pump head was developed. It has the same dimensions as the SWN 80, but has journal bearings over the entire width of the head (100 mm) rather than over a smaller part only, whereas the internal diameter is 40 mm rather than 30 mm. Consequently the bearing surface, and hence its loading capacity, has more than doubled, which renders the SWN 90 pump head the standard one except for very deep water tables.

All journal bearings in SWN pumps are made of laminated phenolic material (*Tufnol*). At either side of the bearing this material protrudes 1 mm beyond the side of the bearing house, thus preventing wear of the bearing house material against the steel side plate of the pump head. By comparison, the side of a ball bearing will eventually come into contact with the steel of the pump head, wear out, and cause lateral play in the handle assembly.

Other characteristics

One of the problems experienced in other handpump designs is failure caused by banging of the handle against the pump head, creating shock loads in excess of design criteria In the SWN pumps this problem cannot occur, due to oversized rubber pads that dampen the shock when the handle hits the pump. These pads have a thickness of 20 mm and run over the full width of the pump head (100 or 160 mm) at 60 mm width.



Rubber pads in SWN pump heads absorb shocks caused when the handle hits the head at the end of the stroke; also notice the tight fit between the pump head and the main bearing housing.

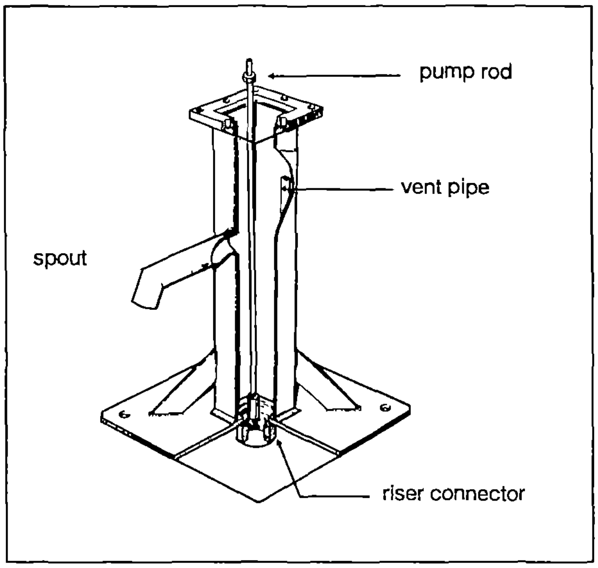
Unlike other handpumps, there are no openings in the SWN pump heads in which children could for instance put a finger or hand, with dangerous consequences. As is shown in the drawing above, there is a tight fit between the pump head and the main bearing housing of the pump handle, to avoid such accidents.

A final feature of the SWN pump heads is the lack of moving or loose parts: the only parts accessible from the outside are the nuts on the stubs with which the pump head is fastened to the pump stand, and the main bolt and nut with which the pump handle is fitted inside the pump head; this self-locking nut has been extremely well tightened at the factory and cannot be removed easily.

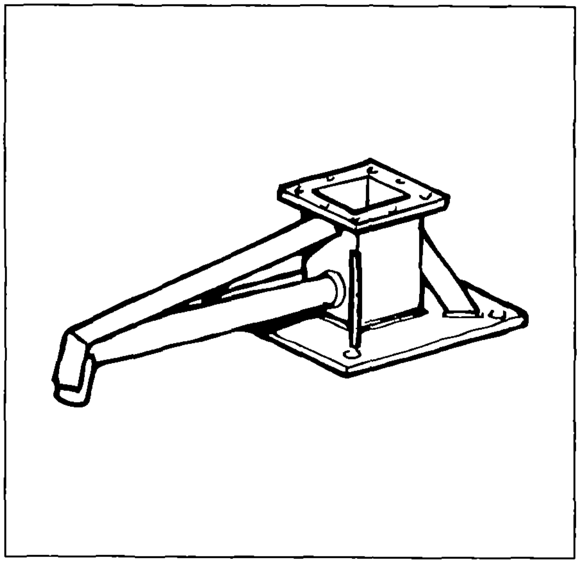
Pump stand

The standard SWN 80/81/90 pump head can be fitted on either of two pump stands:

- ☐ the **long stand**, with a height of 600 mm, being the standard pump stand for installation on boreholes and hand-drilled wells;
- ☐ the **short stand**, with a height of 375 mm, and fitted with a long spout, for mounting on top of large-diameter, dug wells.



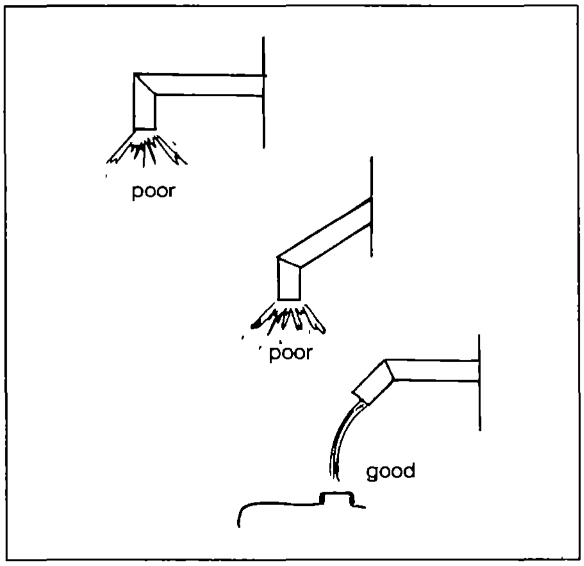
Typical long pump stand



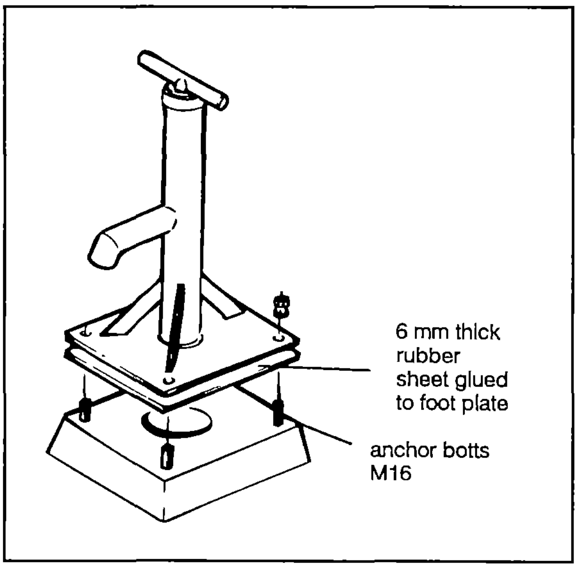
Typical short pump stand

Both types are made of hot-dip galvanized square steel tubing, 100 x 100 x 4 mm, provided with a standardized 160 x 160 x 15 mm steel flange at the top, and an standardized 400 x 400 x 8 mm steel foot plate at the bottom. As extra corrosion protection, all pump stands have a bituminous coating inside.

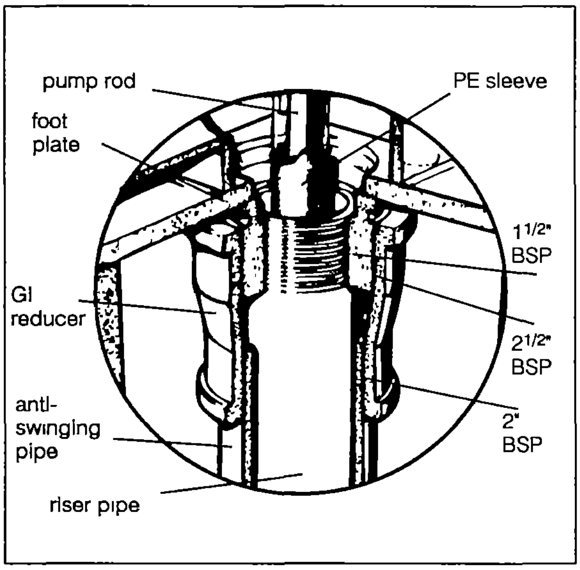
Each pump stand is provided with an internal vent pipe (Ø 10 mm), a spout (Ø 1.5"), four supports and a riser connector (Ø 1.5"/2.5" BSP), as shown below. The vent pipe prevents a vacuum from being created inside the well. Without this kind of prevention, the pumping action (water being sucked up into the cylinder) causes a slight vacuum inside the well or borehole, which often leads to (dirty) water being sucked into the well from between the pump footplate and pump foundation (well cover or platform). A second preventive measure is to ensure a watertight connection between footplate and pump foundation, as described below.



Improved outflow of water due to shape of spout



Connection between pump stand and pump foundation



Details of riser connector

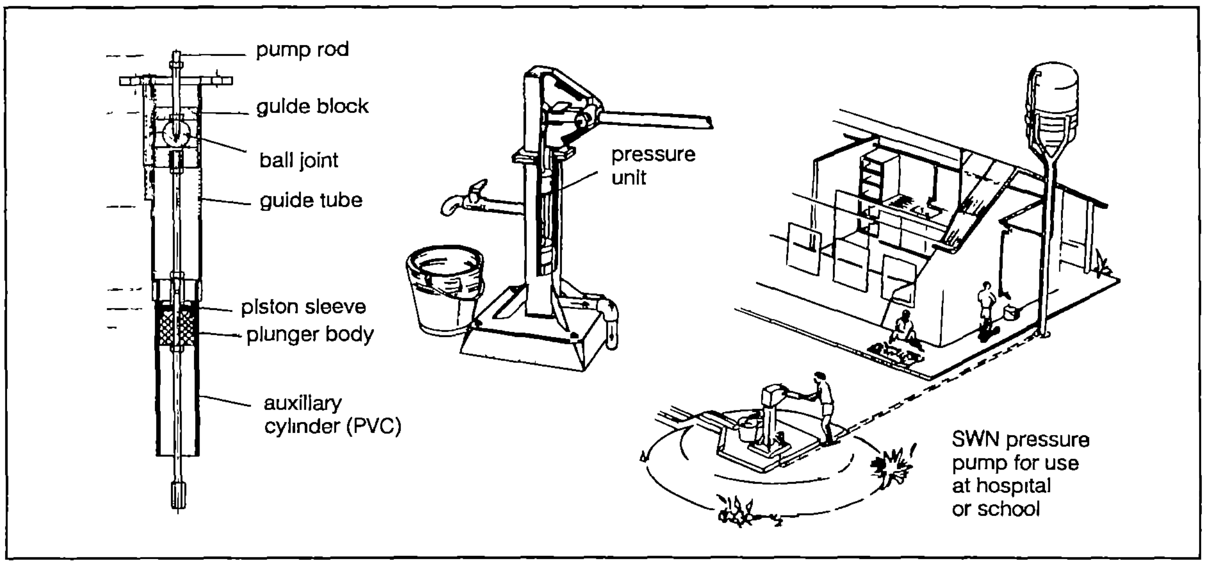
The outlet of the spout is purposely not at right angles but at an angle of 120°, to improve the outflow of water and reduce splashing. A stainless steel pin in the spout prevents stones and the like from being pushed up the spout by children. An angle iron (40 x 40 x 4 mm) is used to support the longer spout of the short pump stand (600 mm from centre of spout to centre line of pump stand). The four supports are made of 6 mm thick hot dip galvanized steel strips. Strips are used rather than triangular plates to prevent water from collecting on the foot plate between the pump stand and the support, which would happen especially when the pump foundation is not entirely horizontal. This design thus reduces the risk of corrosion.

The riser connector has both internal (1.5" BSP) and external (2.5" BSP) thread. The internal thread is for connecting the riser pipe, the external thread is for connecting an anti-swing device when necessary, especially in dug wells *(see pages 21 and 22).*

The pump stand is connected to the pump foundation by four cast in M16 bolts (240 mm long) that protrude 40 mm from the top of the concrete. The 8 mm thick base plate is supported by a 6 mm thick rubber sheet. This ensures a watertight connection between the pump stand and the foundation, while providing a firm support for the pump, sufficient to absorb any forces exerted on it by the handle action. The possibility of contaminated water entering into the well from between the pump footplate is further reduced by raising the pump foundation 20 cm over the level of the platform, as shown above (see also *Volume 2: Dug Wells* and *Volume 3: Hand Drilled Wells*). To guarantee a watertight connection between footplate and pump foundation also in case of not entirely smooth foundations, as an alternative to the 6 mm solid rubber sheet, a 15 mm thick foam rubber sheet can be supplied. With the pump stand in position, this is compressed to about 2 mm.

This type of pump foundation has been selected as the result of extensive field tests. It has proven to be a much better option than that of casting the lower part of the pump stand in the concrete platform, as is the case with several other makes of handpumps. There the forces exerted by the pump handle on the foundation often result in cracks developing between the pump foundation and the platform, so that eventually water (often contaminated) can seep into the borehole from the top, while the handpump becomes unstable.

SWN handpumps may be used to pump water to a level higher than that of the handpump itself, e.g. for filling a roof tank, or for pumping it through a hose or pipe over a longer distance, for which also additional pressure is required. For such cases a *pressure unit* can be fitted into the pump stand, to transform the pump into a pressure pump. The pressure unit can be installed in the long pump stand only. It is essentially an additional plunger assembly which prevents the water from entering into the pump head while keeping it under pressure. For connecting the handpump with a roof tank or piping either the standard pump stand can be used (by fixing a hose to the spout) or a special modification of the pump stand will be required (e.g. replacing the spout by a length of pipe with a ball valve in it).



Application of SWN pump with pressure unit

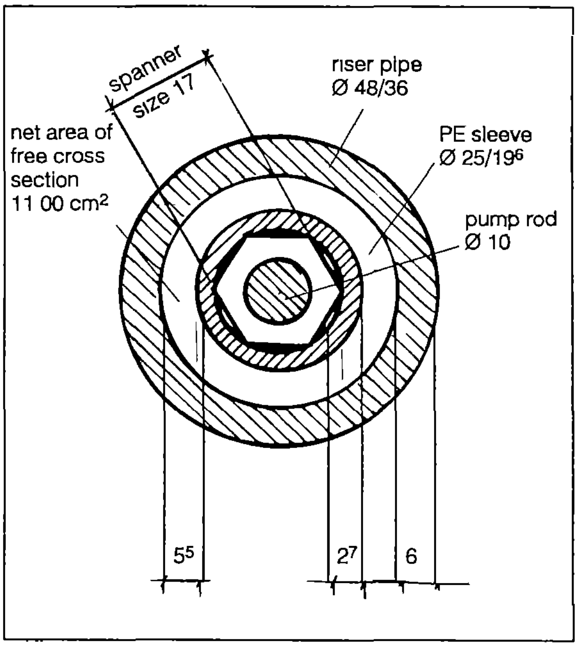
Riser pipe

Size

The purpose of the riser pipe is to transport water from the cylinder to the pump outlet (spout). The major criteria to be fulfilled are, therefore:

- it must allow the flow of water at normal flow rates to be pumped upward without undue effort, so: hydraulically smooth material with a sufficiently large cross section;
- the riser pipe must be long lasting, so sturdy, non-corroding materials must be used.

Even with the largest standard size of cylinder of the SWN range (Ø 75 mm; 3"), the theoretical output of the handpump is about 1.5 m^3 per hour (see page 8). In practice, however, the average output will hardly reach 1 m^3 per hour. A riser with a nominal diameter of around 1.5" has thus proven to be large enough under field conditions: in combination with the standard SWN pump rod/sleeve combination as described later, the average upward flow velocity in the annular space between a 1.5" riser and the sleeve around the pump rod is in the range of 0.5 - 0.8 m/s in that case, so fully acceptable. *(By comparison, various other makes of handpumps use 1.25" riser pipes only).*



Riser and pump rod dimensions

The SWN range of pumps all use the same size of rising main, with standardized threaded connections of 1.5" BSP. At the 1980 donor conference in Tanzania, this was also the standard size agreed on for all handpump projects in the country.

Material

Various types of pipe materials have been tested in the course of time:

- galvanized iron pipe with threaded sockets
- galvanized iron pipe with flanges
- thin walled stainless steel pipe
- glass fibre reinforced polyester (GRP) pipe
- standard PVC pipe
- special (high-impact) PVC pipe

Galvanized iron pipe has several advantages: it is reasonably well available throughout the world, and it is mechanically strong as well as stiff (no swinging or 'snaking' of the riser during pumping; see page 21). Its main disadvantage, however, is that it has proven to be susceptible to corrosion: at lower pH values or in brackish water the material corrodes quickly. In practice, this situation was encountered regularly, whereby the threaded connections have proven to be the weakest points. Similar problems have been reported about other handpump makes, where the repair or replacement of GI riser pipe was found to be one of the most frequently needed types of intervention. Trying to overcome this problem by using flanged connections has proven not to be the solution: whereas the connection is less susceptible to failure, the riser assembly becomes not only more expensive, but also heavier, thus more difficult to handle. As the flanges require more space, a larger-diameter - thus more expensive - borehole is also required.

Stainless steel has been used for riser pipes in certain handpump types It is corrosion-resistant but very expensive and, because of its thin walls, easily dented. It is also brittle and can thus not withstand bending, which will again give rise to failure of such risers under field conditions. When welded, stainless steel becomes even more brittle, restricting the possibilities for joining riser pipes. Cutting thread on stainless steel pipes requires a greater wall thickness than available on commercial pipe sizes, so that expensive threaded sockets would have to be welded to the pipe sections.

GRP pipes can not be threaded, due to their specific structure (the glass fibre reinforcement would be destroyed) so that flanged pipe sections would be required, rendering an already expensive material even more expensive. The material is corrosion-proof, however.

Standard PVC does not possess the earlier mentioned problems, while it is practically corrosion-free. The material will deteriorate under the influence of direct sunlight, however (UV radiation) and its application is thus too risky under field conditions. *Special-quality* (so-called *high-impact) PVC* does not possess this disadvantage. Although being slightly softer it has proven to be a suitable material and reasonably priced.

All SWN handpumps are thus provided with 1.5" standard thick-walled high-impact PVC risers (outer diameter: 48 mm; inner diameter: 36 mm; wall thickness: 6 mm), with threaded ends and joined by high-impact PVC threaded connectors. The type of high-impact PVC used is a mixture of unplasticized PVC and chlorated polyethene (PVC/CPE).

In several other handpumps (e.g. *Afridev* and *Volanta*) PVC riser pipe sections are glued together. This not only prevents disassembly but also makes it possible that pockets of glue get trapped in between riser pipe and socket. This glue never hardens out completely and slowly dissolves the material of the socket. Moreover, PVC risers and rods are susceptible to vibration and swinging, even when provided with centralizers These motions induce successive tensile and compressive forces on the glued joints, which leads to cracks and bursts, and eventually to leakage. This phenomenon can be observed in many *Afridev* pumps.

The riser pipe sections of SWN pumps are provided with threaded sockets, allowing disassembling and reassembling. The sections are screwed together, whereby a rubber ring (47 x 36 x 3 mm) inside the socket ensures watertightness. If two sections are not joined together well enough, not the rubber ring but the thread on the pipe must ensure watertightness. This can be ensured with certain pastes, but — like glue — many of these contain acetone, which dissolves the pipe material. For that reason a special paste was developed for the SWN pumps which can be used repeatedly, without impairing the quality of the riser pipe. Teflon tape might be used as well, but this needs to be replaced every time after disassembly, and may not be readily available under field conditions.

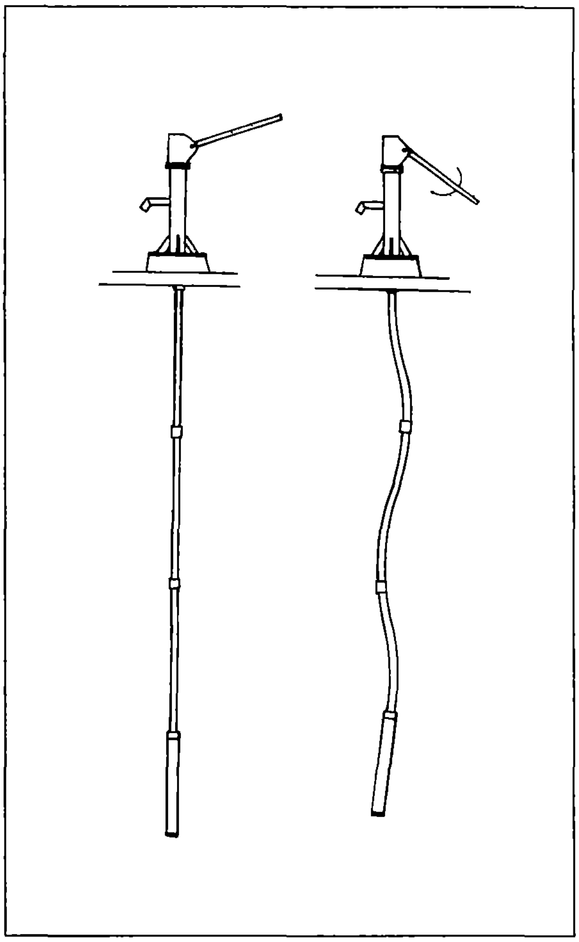
Swinging and 'snaking' of riser pipes

A disadvantage of plastic pipes compared to metal pipes is that they are more elastic. This not only results in more pronounced stretching under load, but also in so-called creep (continuing and permanent slow elongation of the pipe under load) as well as swinging or 'snaking' of the pipe, whereby the riser - because of the pumping action - gets into a swinging or snaking motion which may eventually result in failure: from leaking sockets to broken pipes.

For well depths up to about 60 m (range of use for SWN 90 pumps) creep is not a problem, especially if thick-walled pipes are used (hence. relatively low resulting stresses in the material), for deeper wells, however, GI pipe must be used, provided that the groundwater is not corrosive.

To restrict swinging and snaking of PVC riser pipes, the following actions should be taken:

- for small-diameter wells/boreholes: provide each pipe section with a centralizer to restrict 'snaking'. The centralizers can be slipped over the riser and rest on the PVC couplings. They are soft rubber squares of 15 mm thickness, with a Ø 50 mm hole in the centre, and sides of 70 mm length (to fit inside a Ø 110/103 mm filter/casing pipe) or 80 mm length (to fit inside a Ø 125/117 mm filter/casing pipe; *see Volume 3: Hand Drilled Wells*);

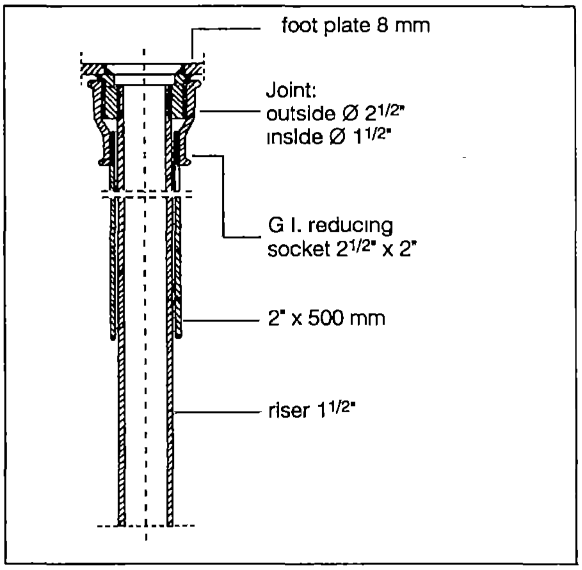


'Snaking' of PVC riser pipe

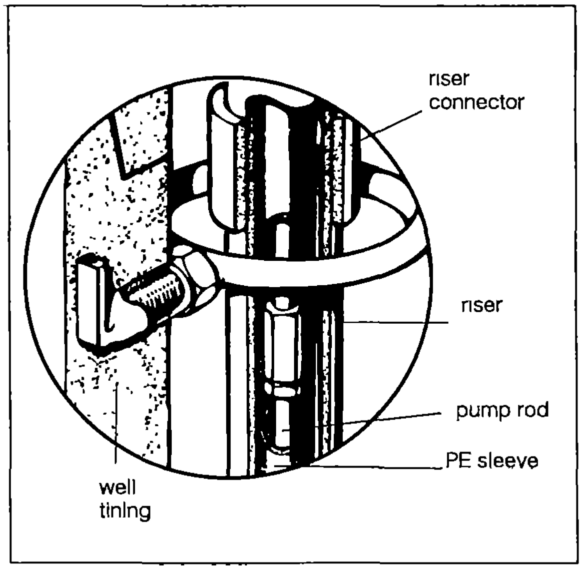
- for larger-diameter (e.g. dug) wells, and especially when the water table is low, special (stainless) steel retaining rings can be fastened to the well rings to limit the movement of the riser to a minimum. Good results have been obtained by retaining rings or hooks that were anchored into the well rings by means of 60 mm long cast-in plugs that accepted the M10 thread cut on the ends of the retaining hooks. In some cases similar results could be obtained with stainless steel bars screwed into the well rings.

  In addition an anti-swinging device must be connected to the pump base plate, consisting of a 50 cm long 2" PVC or HIPVC pipe that is screwed on to the outside of the riser connector with the help of a 2.5"/2" GI reducing socket. This pipe thus fits around the top of the riser, thereby restricting its deflection.

Extensive research into the behaviour of PVC rising mains for handpumps was carried out in the UK and the Netherlands in the period 1989-1990, which resulted in several recommendations and design rules to prevent pump failure due to fatigue[4]. These have been incorporated in all SWN handpump designs.



Anti-swinging device



Retaining hooks or rings in larger-diameter wells

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[4] Besselink, J., Grupa, J , and Smulders, P. (1990), *Behaviour of deepwell handpumps with PVC rising mains*, Arnhem, IAD Handpump Project Publication.

Pump rod

The aim of the pump rod is to transmit forces from the pump superstructure (generally: the pump handle) to the piston or plunger. It must thus have a sufficient mechanical strength while being corrosion-resistant.

Material and size
Several materials have been tested in the past:

- *wooden poles or stakes*. Although frequently used in the past, especially in windmills, this material is not suitable for modern handpumps. It is also next to impossible to maintain for longer periods under field conditions unless expensive types of wood would be used;
- *solid PVC bars* would be corrosion-resistant, but stretching and creep due to tensile stress in the material have proven to reduce the efficiency of the pump under field conditions (stroke length becomes severely restricted). If better-quality PVC or reinforced PVC would become available, this option might be promising, however;
- *PVC pipe*. For shallow wells, thick-walled PVC pipe would be an acceptable solution: being comparatively lightweight, the combination of shallow depth and larger-than-average wall thickness will result in relatively low tensile stress, thus negligible stretch and creep. This material is used for pump rods for the *Afya* direct action pump (see page 31).

  The diameter of the standard SWN pump rod (10 mm) is relatively small compared to the internal cylinder diameter used. As mentioned on page 5, this means that — without a PE sleeve around the pump rod — the pumping action would be virtually single-acting, water being produced mainly during the upstroke of the plunger. For double-acting pumping the diameter of the pump rod must be considerably larger in comparison with the internal cylinder diameter. This favours the use of PVC pipe as pump rod. Especially when it can be ensured that no water can enter into the pipe, the total weight of the assembly might be such that only little effort is required for pumping, thus combining the advantages of smooth flow with easy operation.

  By using a PE sleeve around the pump rod in SWN handpumps, the effective diameter of the pump rod is raised to 25 mm, so that some water is also pumped during the downstroke. The effect is rather limited, however: for a Ø 50 mm cylinder the outflow during the upstroke is 25% of that during the downstroke

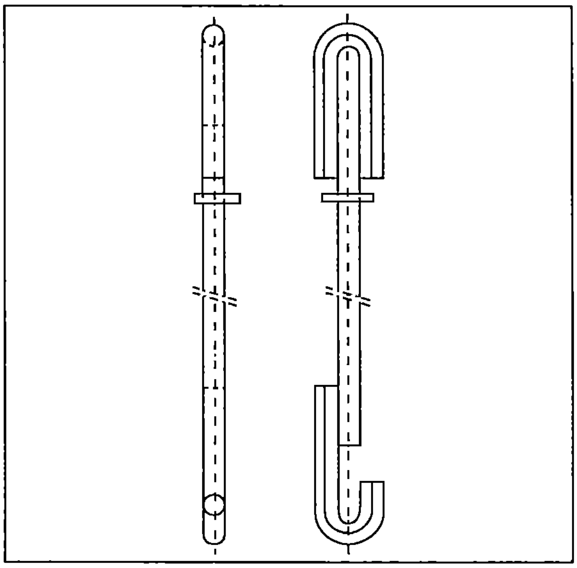
  Tests with 'floating' pump rods have not been entirely successful, however. For greater well depths the elasticity of the material (PVC) in combination with the inertia of the cylinder/plunger combination at times resulted in a considerable loss of pumping efficiency. In case of leakage into the PVC pump 'rod' its weight obviously increases considerably, and at least a part of the ease of operation will be lost. The connection between PVC-pipe pump rods is, therefore, a crucial one. Experience with glued connections has shown that the glue breaks under the repeated bending and stretching of the pump rod, rendering it extremely difficult to guarantee watertightness of the connections;
- *painted or galvanized iron bars*. In practice, this material is not sufficiently corrosion-resistant, showing failure similar to that of GI riser pipes. At normal bar thickness, the rods would easily bend if subjected - for whatever reason - to compressive forces;
- *galvanized iron pipe* of ½" has been used with varying success in the past. As with other GI pipes, they are relatively easily available, but suffer from the same draw-backs as GI riser pipes, being susceptible to corrosion. In addition, GI pipes used as pump rods are relatively heavy;
- *stainless steel* is corrosion-resistant, but expensive and brittle. Its high tensile strength allows the use of relatively thin rods (Ø 10 mm), however. Also, by using well-designed threaded couplers the disadvantages of the brittle nature of stainless steel can be largely overcome. Under African field conditions this material has proven to be very dependable, and was thus chosen as the standard for regular SWN handpumps. During the 1980 donor conference, the size and connection type of the SWN pump rods were accepted as the standard to be used, whereby the

choice of mild steel versus stainless steel was left at the discretion of the individual project.

Connections between rods

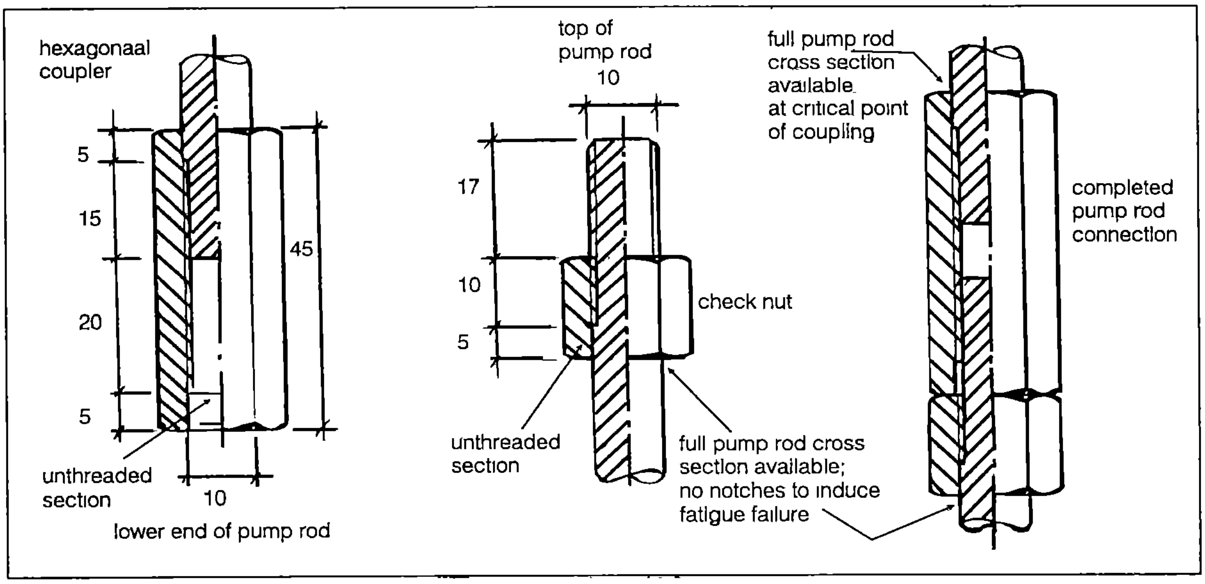
In handpump practice, welding is not feasible for pump rods. Not only would it severely hamper dismantling the handpump substructure, but in the case of stainless steel pump rods it would also result in impaired strength of the material. Therefore, mainly two types of pump rod connections can be observed:

- *hooks*. Tight-fitting hooks are used in some handpumps. Their main advantage is the fact that pump rods equipped with these hooks can be taken apart easily. A disadvantage, however, is that this type of hook either has to be welded together or has to be more or less rectangular in shape to ensure a tight fitting. Neither type is suitable under dynamic conditions, resulting in fatigue failure. Hooks that are better shaped from the point of fatigue resistance, are relatively loose, resulting in rattling of the individual rods and increased wear.
- *threaded connectors* are the better option, and have been chosen as the standard for both regular SWN pumps and *Afya* direct action pumps.

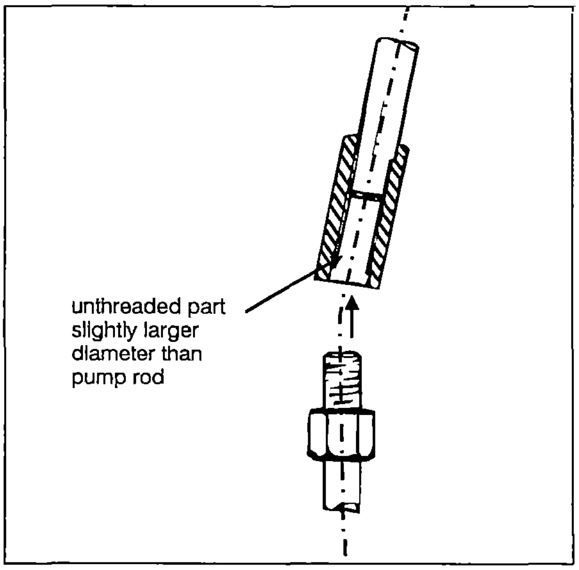


Rod connection with hooks

The pump rod connection for standard SWN pumps consists of a stainless steel hexagonal coupler (an elongated nut) with internal metric thread, connected tightly (with *Uni-Lock* or *Loctite)* to one end of a Ø 10 mm stainless steel rod, with a 27 mm long threaded end and counter nut on the other end. The coupler, which has a total length of 45 mm, has internal thread over most of its length, but the thread has been removed over 5 mm at either end, thus creating two chambers of 10 mm internal diameter.



Details of standard SWN pump rod connection



Unthreaded part of rod connector facilitates connecting pump rods that are not perfectly in line

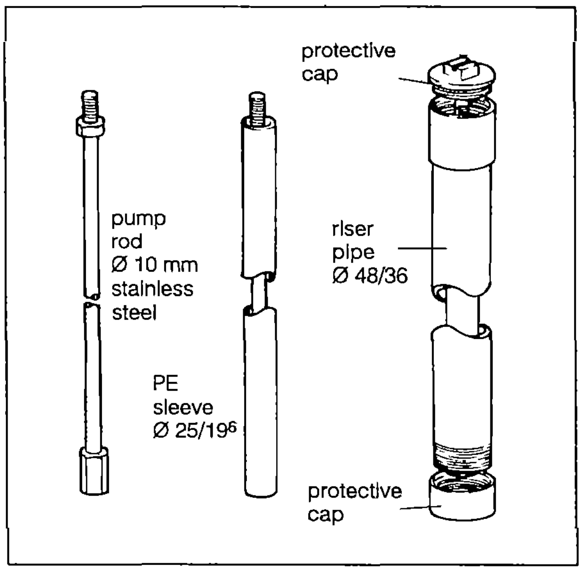
At the factory each coupler is fitted to a pump rod, in such a way that the 15 mm long threaded part at one end of the pump rod is fully inside the threaded part of the coupler, with the unthreaded part fitting snugly in the small chamber at the end of the coupler *(see figure above)*. The chamber at the other end makes jointing with another pump rod easier as it acts as a centring guide for the threaded end of the other pump rod and thus eliminates the chance of damaging the thread by forcing the two parts together at an angle. In a similar way the 15 mm long check nut has been fitted to the other end of each pump rod: this nut again has a small chamber without thread in which the unthreaded part of the pump rod fits tightly. At the factory both coupler and check nut are fastened tightly with a metal glue. The check nut or coupler should *never* be (spot-)welded to the pump rod, as that would alter the structure of the material, which becomes brittle and snaps easily.

The total free length of the threaded part of the coupler is a few millimetres more than the length of the thread at the end of the pump rod to be connected. On the one hand this allows the two rods to be joined tightly even if there would be some material (e.g. cuttings) trapped in the coupler. On the other hand it ensures that the threaded part of each pump rod is fully enclosed by the threaded part of coupler or check nut, with an additional 5 mm of unthreaded rod fitting snugly in the chamber at either end of the coupler/check nut combination. As the coupler and check nut can be joined very tightly, a strong connection between the two pump rods is ensured. In addition, the set-up with partly unthreaded coupler and check nut ensures that the most vulnerable part of the coupling (viz. just adjacent to the coupler/check nut combination) is not threaded and tightly connected without any play. This has two advantages: the full cross section of the pump rod material is available for absorbing any forces, and the absence of sharp cuts or notches vastly increases the fatigue strength of the rod compared to the situation where bending of the rod at a threaded cross section would be possible.

Centralizers/sleeves

A problem mentioned with the use of PVC risers on other handpumps is wearing out of the PVC riser due to friction by the steel pump rods and connectors. Similar problems were experienced in the past with SWN handpumps. A frequently recommended measure is the use of centralizers to keep the pump rod at the centre of the riser Although this indeed reduces wear of the riser, the centralizers themselves wear out and have to be replaced (for some handpumps this was reported to be necessary once every two years). In addition, the centralizers, even when provided with holes in them, obstruct the upward flow of water in the space between riser and pump rod.

For the regular SWN pumps a different solution was chosen after successful field trials: a PE



PE sleeve on SWN pump rod

(polyethylene) sleeve with an external diameter of 25 mm and a wall thickness of 2.7 mm is pushed over each pump rod, once this has been connected to the previous pump rod or piston rod. With its internal diameter of 19.6 mm this pipe fits tightly around the coupler and check nut on the pump rod, while presenting an entirely smooth surface and virtually eliminating wear of the riser.

Riser/rod unit lengths

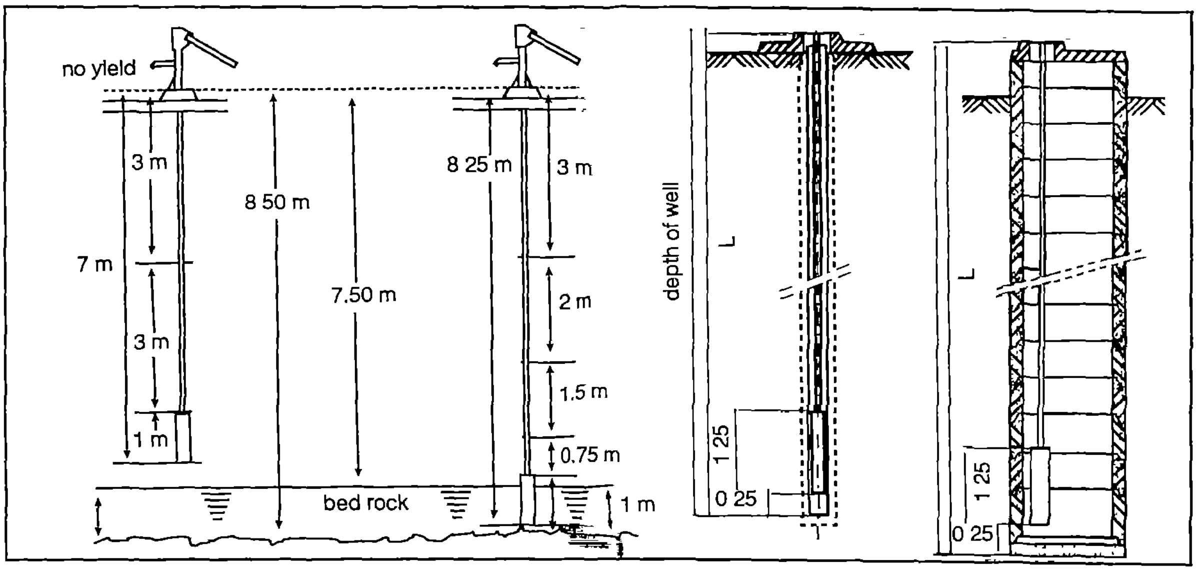
In principle, the longer the pump rod/riser, the smaller the number of connections. In practice, however, there is a limit to the length of rod or riser that can be handled in the field. A length of 3 m should thus be considered the longest feasible. For many handpump types, pump rods and risers are available only in standard lengths of 3 or 4 metres. It is clear that it is generally impossible to use full multiples of such long lengths in a particular situation. This implies that for each pump at least one riser pipe and pump rod will have to be cut to length and threaded on site, thus making the use of cutting and threading tools necessary. Even if that would present no problem and skilled labour would be available as well, the quality of the joints will generally not be as good as those made at the factory.

For the standard SWN pumps, riser pipe, pump rod and PE protecting sleeve are shipped as sets, each set containing one length of riser pipe, with corresponding pump rod and PE sleeve, and closed by end caps. For the SWN range of pumps four unit lengths are available:

- 0.75 metres, weight per set: 1.5 kg
- 1.50 metres, weight per set: 3 kg
- 2.00 metres, weight per set: 4 kg
- 3.00 metres, weight per set: 6 kg

As shown in the illustration below, with these unit lengths of risers and pump rods it is possible to put the cylinder at the required depth with an accuracy of within 25 cm.

To limit the number of connections, do not use shorter rod/riser lengths than indicated, even though the total length may work out to be the same!



Riser/rod length can be adjusted to within 0.25 m of the theoretically required depth

HOW TO DETERMINE REQUIRED RISER/ROD PACKAGES:

- determine depth of the well/borehole bottom, from the top of the pump foundation
- subtract 0.25 m for distance between cylinder and well bottom
- subtract 1 m for length of pump cylinder
- subtract a multiple of 3 m from the result until the remainder is less than 3 m, and look up the required numbers of shorter riser/rod combinations in the table below:

(Example: if the measured well depth is 42.80 metres, subtract 0.25 m + 1.00 m = 1.25 m; result: 41.55 m. The largest multiple of 3 m that can be subtracted from 41.55 is 39 m (13 x 3 m), leaving a rest of 41.55 - 39 = 2.55 m. From the table below it can be found that for 2.55 m one set of 0.75 m and one set of 1.50 m are required. Adding to this the 13 x 3 m that were subtracted in the first place, the total number of riser/rod sets required is:

- 1 x 0.75 m
- 1 x 1.50 m
- 13 x 3 m

or: a total length of 0.75 + 1.50 + 13 x 3 = 41.25 m. This means that the bottom of the cylinder is positioned at 42.80 - 41.25 - 1 m (cylinder length) = 0.55 m above the well bottom).

Remaining length	l = 0.75 m	l = 1.50 m	l = 2.00 m
0.00 - 0.75 m	-	-	-
0.76 - 1.50 m	1	-	-
1.51 - 2.00 m	-	1	-
2.01 - 2.25 m	-	-	1
2.26 - 2.75 m	1	1	-
2.76 - 3.00 m	1	-	1

Note: The table is valid under the normal conditions in which handpumps are used. In special cases the pump cylinder need not be hung as deep as shown, however. For example: in the case where a relatively deep borehole was required to strike a water bearing layer, but where the water subsequently rose to a much higher level, it would be a waste of money to put the cylinder at a level of only about 0.25 m above the bottom of the borehole. In such cases it would be sufficient to position the cylinder a few metres below the water table only, using a multiple of 3 m lengths for risers and pump rods.

Cylinder

With the exception of the *Afya* direct action pump, all pumps of the SWN range use universal cylinder assemblies. These are typically 1.00 m long and available in 4 standard sizes (different sizes can be made available on request):

- *Ø 55 mm (Ø 1½"; actually too small to be effective in use)*
- Ø 66 mm (Ø 2")
- Ø 81 mm (Ø 2½")
- Ø 96 mm (Ø 3")
- *Ø 100 mm (Ø 4"; in fact too heavy to handle under most circumstances)*

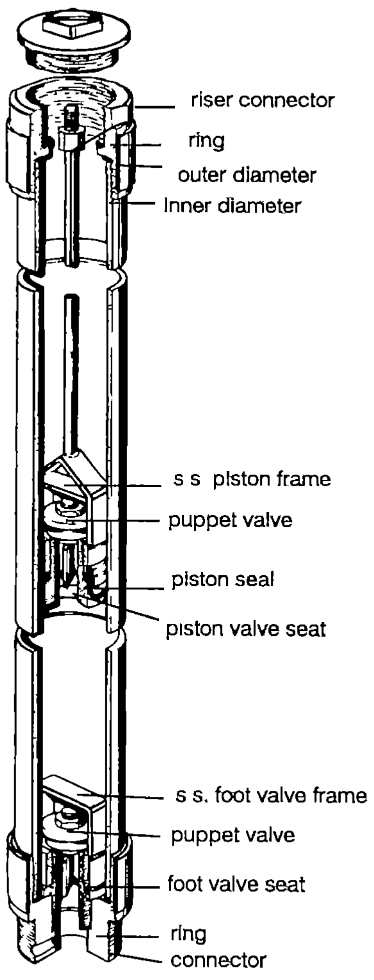
Key measures of these cylinder sizes are shown in the table below.

Cylinder assemblies consist of three main components:

- cylinder body
- piston assembly
- foot valve assembly

Cylinder body

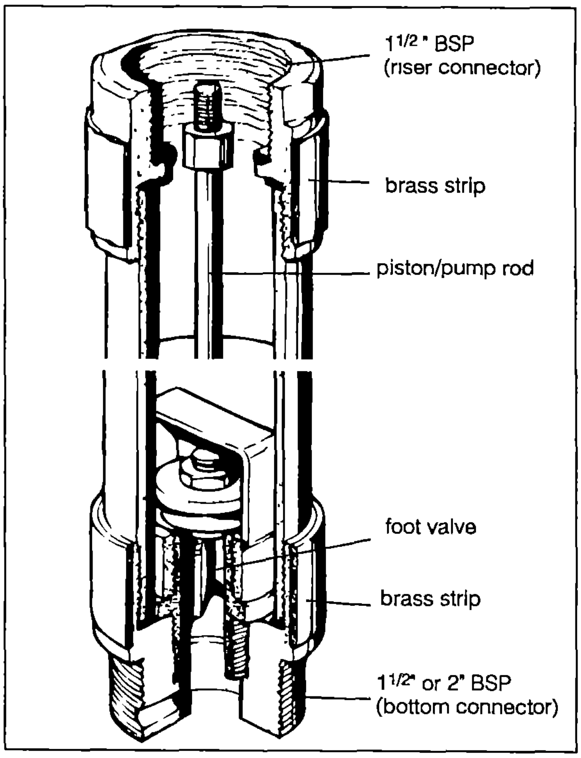
Traditionally, various materials have been used for handpump cylinders. Among the most common are cast iron and brass. Whereas brass is very expensive, cast iron is relatively cheap but not very smooth. This is the reason that for Dempster-type cylinders, as used in India Mk. II/III and Afridev handpumps, a thin brass liner (sleeve) is fitted inside the cylinder as the plunger would wear out too quickly otherwise.



SWN standardized pump cylinders

Cylinder size:	50 mm (2")	63 mm (2½")	75 mm (3")
Riser connector	1½"	1½"	1½"
Outer cylinder wall diameter (mm)	66	81	96
Inner cylinder wall diameter (mm)	50.5	63.5	75.5
Wall thickness (mm)	7.75	10.75	10.25
Upper poppet valve (mm)	25	30	38
Piston seal diameter (mm)	50	63	75
Poppet valve size (foot valve) (mm)	25	30	38
Bottom connector	1½"	2"	2"

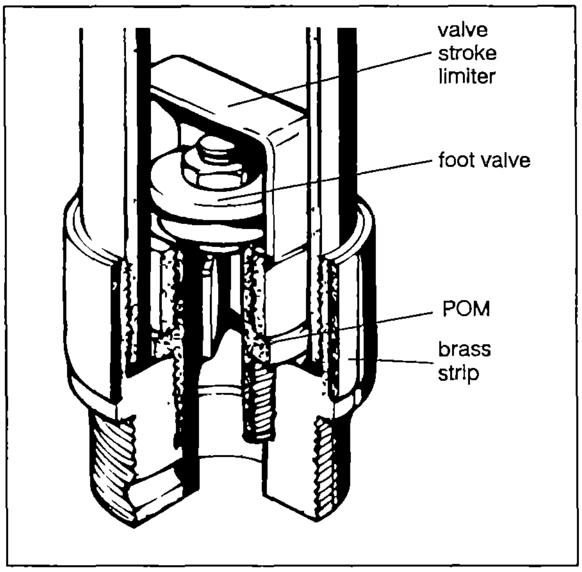
Field experience as well as formal handpump testing programmes indicate that repair and replacement of cylinder parts, notably the replacement of piston valve seals, count among the most frequently required maintenance activities. For that reason much attention has been given to the design and continued improvement of the SWN cylinder body, piston and foot valve assemblies.



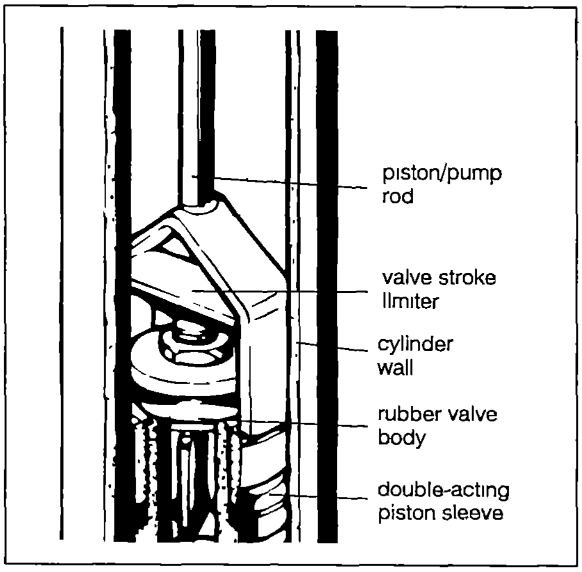
Details of cylinder wall top and bottom connections

The standard SWN cylinders are made of special, internally calibrated thick-walled PVC, with dimensions as shown in the table above: the net internal diameter being 0.5 mm larger than the nominal size (regular PVC pipe is manufactured to tolerances that are too large, which renders the material unsuitable). The cylinder wall has external thread at both ends, to which connectors of polyacetal (POM) are fastened. These connectors would be the first parts of the cylinder to come into contact with the well casing or ring, and are therefore the most susceptible to wear. POM is used rather than nylon, as the latter becomes soft under the influence of sunlight. For a similar reason no normal PVC is used, as this proved to be not sufficiently resistant against mechanical wear. To allow the cylinders to be used in boreholes with relatively small diameters, the thickness of the POM material has been kept to a minimum, with a brass strip around it to ensure sufficient strength also when used at greater depths.

The connector at the top of the cylinder has internal thread of 1½", as indicated in the table, to accept the riser pipe. The connector at the bottom has external thread of between 1½" and 2", to allow a suction hose or extension pipe to be connected underneath the cylinder. To ensure complete watertightness, a flat rubber ring is inserted in the joint between connector and cylinder wall.



Details of foot valve assembly

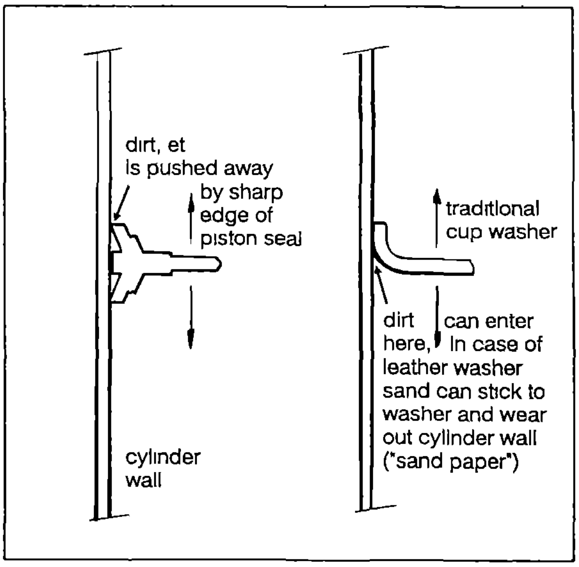


Details of piston assembly

The valve seat, both for the piston assembly and foot valve assembly, is connected to the connector with a special, fine thread. Its maintenance or repair is, therefore, beyond the capacity of a regular maintenance team. In the rare case that problems with this part would occur in the field, it is better to exchange the entire pump cylinder assembly (or at least the complete bottom connector/foot valve assembly or piston assembly) and have it repaired by specially trained staff.

Piston (Plunger)

The piston (plunger) has a heavy-duty, double-acting piston sleeve of acrylonitrile rubber. This is also used in the hydraulics of heavy equipment, and has been designed to withstand a pressure of 175 bar. During pump operation both rims of the piston sleeve are slightly compressed, which results in a scraping action of the piston sleeve in either direction. This implies that no dirt or sand can settle on the cylinder wall part that is used by the piston, and the wall remains smooth and clean. By comparison, a sand particle will get stuck in a leather cup/washer and thus start scratching the cylinder wall surface. *(India Mk. II handpump testing at Coimbatore also showed that using nitrile rubber piston cups considerably extended the lifetime of the cups compared with leather as used before. Consequently, the new India Mk. II handpump standards now prescribe the use of nitrile rubber cups.).*



Double-acting versus traditional cup seal

The combination of a double-acting acrylonitrile rubber piston sleeve operating inside a thick-walled PVC cylinder has proven to be very reliable: even for handpumps used as dewatering pumps in the construction of open wells (and thus repeatedly pumping sandy water) the wear of these piston sleeves after several years of continuous use has been negligible.

Poppet valves

The valves incorporated in the piston and foot valve assemblies are largely identical. These poppet valves have a diameter equal to half the piston diameter, and consist of a brass valve cover, central pin and valve guide, and a rubber body. They rest on a nylon valve seat. To reduce wear of the rubber valve body due to locally concentrated water flows, the top edge of the valve seat has been shaped so as to perfectly accommodate the rubber. The foot valve seat is screwed into the cylinder bottom adapter; its stroke is limited to ¼ of the poppet diameter by a stainless steel stroke limiter, fastened to a stainless steel locking socket that is screwed to the top of the valve seat.

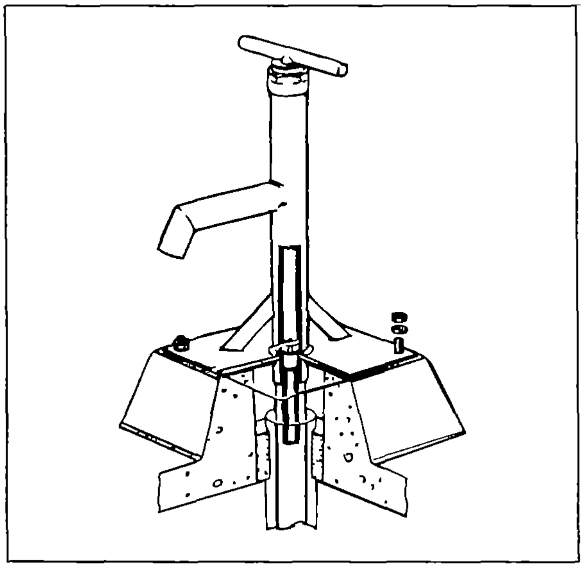
The construction of the main plunger assembly is similar: over a nylon plunger body with an internal diameter equal to half the internal cylinder diameter, the rubberized steel core of the double-acting piston sleeve is fastened by means of a stainless steel locking socket that is also the base for the stroke limiter of the poppet valve. The dimensions of the poppet valve and of the top part of the nylon valve seat are identical to those of the foot valve assembly. The valve stop of the plunger assembly has a stainless steel pump rod section welded to it, with a check nut at its top.

AFYA direct action pump

The Afya direct action pump was developed as the successor of the Kangaroo pump: ***a very low cost option for situations where the groundwater is not deeper than about 10 metres***. For such depths the effort required to pump water is minimal, which allows the use of handpumps without the mechanical advantage as offered by a handle pump. By leaving out a handle, the maintenance of the pump can be kept very simple, as no hinge or pivot points are included, hence no bearings of any kind are required.

The relatively shallow depths at which *Afya* pumps are used, and the cylinder/riser diameter of 2" only, make it possible to use this pump on wells bored with the light hand drilling equipment: a well drilled with a Ø 150 mm drill bit can accommodate a Ø 75/69 riser/filter pipe combination, even with a gravel pack around it. This, in turn, is large enough to accept the *Afya* cylinder and riser, resulting in a very low-cost well/handpump combination, as the drilling equipment can be transported in two boxes, in a small pick-up or larger saloon car.

The *Afya* pump is operated in the same way as a bicycle pump: the T-shaped handle is simply moved up and down.

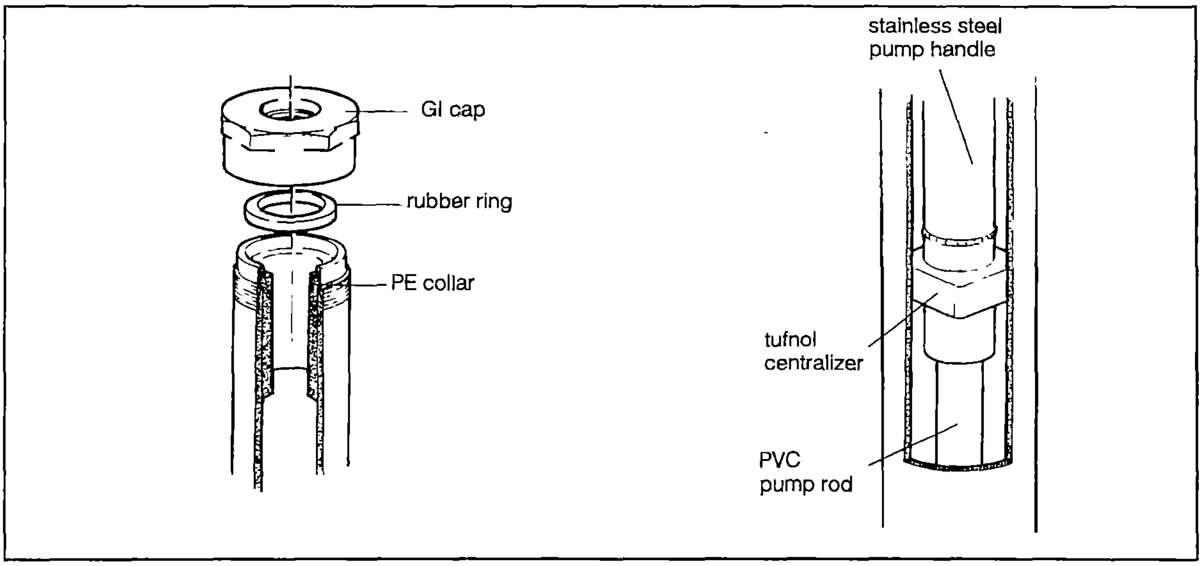


Head of Afya direct action pump

Superstructure
The *Afya* direct action pump uses a combination pump head-cum-pump stand. The pump stand is a 0.60 m long, hot-dip galvanized Ø 2½" pipe, with a Ø 2" spout of the same material. Special attention has been paid to minimize wear by the pump handle, T-shaped with a 300 mm long horizontal part and fitted directly to the top of the pump rod. To minimize friction either a plastic material or stainless steel had to be used for this handle. Because of its greater mechanical strength, stainless steel (SS 304) was chosen (Ø 40/36 mm pipe; shaft length: 59 cm).

Since no user operates the pump handle in an exactly vertical way, special precautions have been taken to prevent wear due to abrasion of the pump stand by the pump handle/rod assembly. The top of the pump stand is, therefore, provided with a 100 mm high and 13.9 mm thick PE collar (internal diameter 40.2 mm) to guide the Ø 40 mm handle shaft. The collar is fitted to the top of the pump stand through a hexagonal Ø 2½" GI cap; an O-ring in between ensures a watertight connection. A 10 mm thick rubber ring (Ø 80 mm external dia.) between GI cap and pump handle absorbs any shocks caused by the handle hitting the pump stand (see figure on next page).

At its bottom end a stainless steel connector with M24 internal thread is welded to the shaft of the pump handle. A stainless steel reducer with M16 internal thread at the bottom is screwed onto the connector with a 20 mm *tufnol* centraliser fitted in between, as shown at right. The centraliser is a 55 mm square slab of *tufnol*, cut off at the edges in such a way that it fits within a circle of 66 mm diameter. Being locked up between pump handle connector and reducer, it moves up and down with the handle. During the upward stroke the centraliser merely guides the handle/pump rod inside the pump stand, as the water moves upward together with the handle and centralizer; during the downward stroke the water moves in the opposite direction as the pump rod and has to pass through the space between centralizer and pump stand wall. The resulting friction serves to dampen the downward movement of the handle/pump rod assembly and thus prevents the handle from banging on the pump stand while moving downwards.

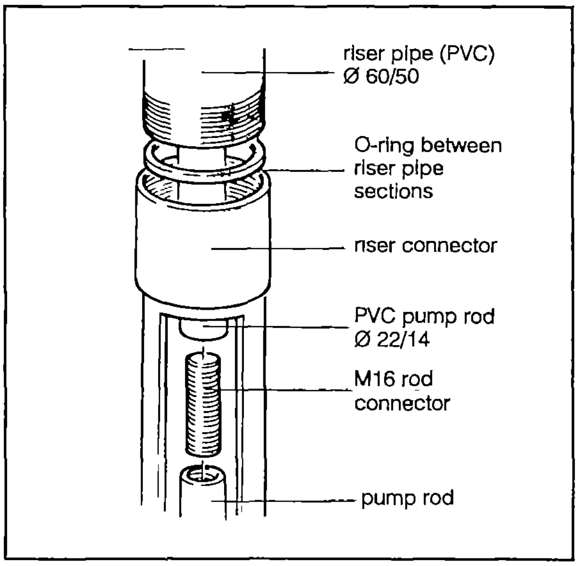


Details of Afya pump stand

Unlike the standard pump stand, the *Afya* pump stand is provided with 3 supports for the foot plate: two supports at 60° left and right of the spout (as seen from above) and one at the opposite side. The latter allows the user to put his/her feet on the footplate (at either side of the third support) during pumping.

Riser pipe

The *Afya* direct action pump has a riser pipe of a different nature than the SWN deepwell pumps. It is a thick-walled pipe of regular PVC (outer diameter 60 mm; inner diameter: 52 mm; wall thickness: 4 mm), joined together by 60 mm long couplings. To enable the use of Afya pumps on small-diameter boreholes (with Ø 75/69 casing/ screen) the sockets are made of the same pipe, on which, after heating and widening to Ø 66/58 mm, internal (2" BSP) thread is cut. A rubber O-ring is inserted at each joint as an additional measure to ensure a watertight connection. Because of the shallow depths for which this pump is used, the load on the riser and pump rods is much smaller than for SWN deepwell pumps. Consequently, it is not necessary to use the - considerably more expensive – high-impact PVC in this case.



Details of Afya riser pipe/pump rod

The diameter of the riser pipe is larger than used for the SWN deepwell pumps. This is because the *Afya* pump is based on the concept whereby riser pipe and cylinder are of the same material and size. This reduces over-all costs, allows the pump rods and piston to be withdrawn without having to dismantle the riser pipe, and makes it possible to install Afya pumps on inexpensive 3" boreholes (which can often be constructed in 2 days).

Pump rod

As was mentioned on page 23, for relatively shallow wells, thick-walled PVC pipe can be used as pump rod. It is used as such for the *Afya* direct action pump (outer diameter: 22 mm; inner diameter: 14 mm; wall thickness: 4 mm).

As the pump is not designed for a 'floating' pump rod, leakage into the rod would not, in itself, present a problem. Nevertheless, the connection between successive pump rod sections is such that leakage is minimized: each pump rod is provided with internal thread at either end, and the connection between two PVC 'rods' is through a 60 mm long threaded steel rod connector M16.

Riser/rod unit lengths

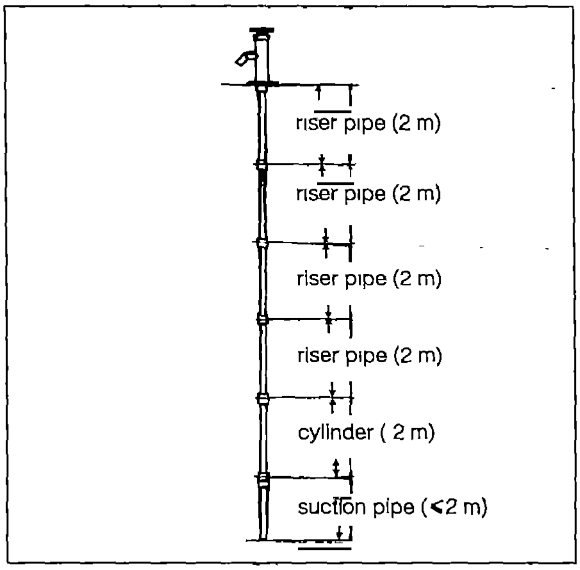
The *Afya* pump has standard riser/rod lengths of 2 m only. Basically, the underground part of the pump consists of one or more riser/rod combinations of 2 m each, a cylinder of the same material and size, also with a length of 2 m, and a suction pipe (again of the same material and size) underneath the cylinder. Adjustment of the length of the underground part of the pump to the well depth is done by cutting off a part of the suction pipe.

Cylinder

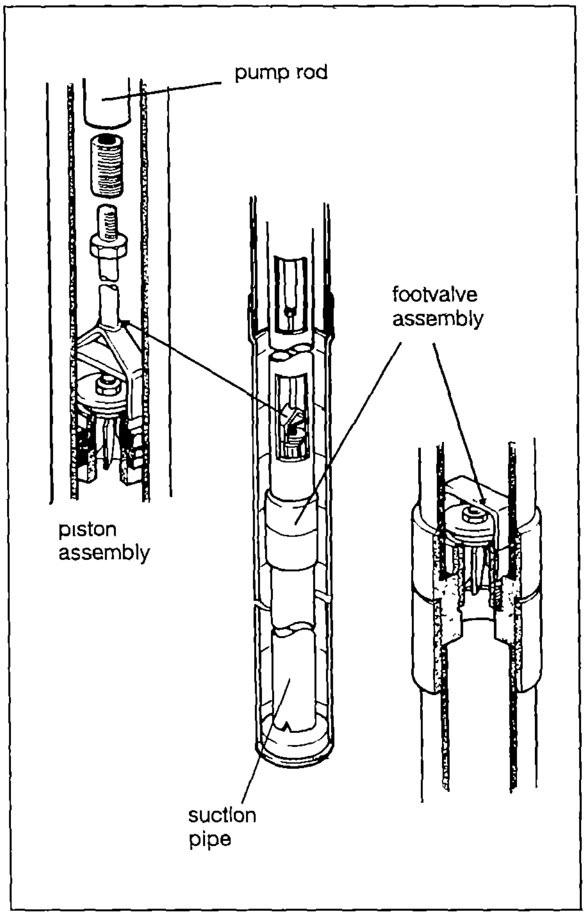
The cylinder of the *Afya* direct action pump is in fact a standard 2-m riser pipe to which a foot valve is connected. The set-up of the piston valve assembly is comparable to that of the deepwell SWN cylinders, the exception being the piston seal itself. For the *Afya* pump this is a double-action seal with softer flaps, of which the outer diameter can be adjusted within the range 50 - 53 mm. The internal diameter of the PVC pipe (unlike the standard SWN cylinder material this pipe is not calibrated) is 52 mm, which is well within the range covered by the piston seal.

The fact that a full pipe length of 2 m is available as cylinder, means that effects of elongation and creep can be largely compensated as the piston can operate as well at a lower position in the pipe as at a higher one.

The construction of the foot valve and plunger valve assemblies is largely the same as for standard 2" SWN cylinders; only for the connection between plunger assembly and pump rod a threaded adapter M16 - M10 is required, to make the 10 mm stainless steel pump rod section on the plunger assembly fit into the internal thread of the PVC pump rod.



Underground part of Afya direct action pump



Details of Afya direct action pump cylinder

Using the materials as described above, the *Afya* pump provides a low-cost alternative for use on shallow wells, allowing the use of an easily transportable 150 mm hand-drilling set for constructing the well, while retaining the general quality level of the standard range of SWN handpumps. Its cost is about half of that of a SWN 90 handpump under similar conditions. For heavy-duty applications, however, a SWN 90 handpump remains the preferred choice.

INSTALLATION OF SWN HANDPUMPS

General installation procedures

☐ **First check that everything is ready**

Convince yourself that the structural elements are ready for installing the pump:

- does the well give enough water?
- is the slab ready?
- is the hole for the cylinder big enough?
- is the pump foundation ready (concrete set, of good quality, surface flat and smooth, no visible cracks, etc.)?
- are the anchor bolts in place, and at the correct spacing (33 cm on centres)? Are they vertical; is the thread (either M16 or 5/8") undamaged and are nuts of the correct size available?
- does the footplate of the pump stand fit easily over the anchor bolts?
- has a gutter been made?

If any of these is lacking, have them corrected/made first, before undertaking any further action. If an anchor bolt is slightly out of line or non-vertical, it may carefully hammered in place, but *only* after one or more nuts have been put on the bolt, to protect the thread. Also in that case, do not use force unnecessarily!

☐ **Discuss actions with interested party**

Explain the installation procedure with the Water Committee, caretaker, owner, or whatever other party has asked for/is interested in the handpump. If nobody has shown up or appears to be interested, any installation is a *waste of energy*.

DON'T INSTALL A PUMP IN SUCH CASE!

☐ **Arrange - in advance - additional inputs:**

For the handpump and well to work well, a number of complementary actions are required:

- construction of soak pit (see *Volume 2. Dug Wells* and *Volume 3: Hand Drilled Wells*)
- digging/construction of gutter
- construction of washing slab or cattle trough, as may be required
- setting up fence, row of bushes, wall, or similar, around well site
- appointing caretaker and arranging his/her remuneration
- arranging for maintenance, repairs, spare parts

If these aspects have not been arranged in advance, it is very unlikely that they will ever be arranged later. Therefore: have these things taken care of first!

☐ **For replacement of an existing handpump of another make, by an SWN handpump, start at page 35, Section A1**

☐ **For installation of an SWN handpump at a new site, start at page 37, Section A2**

A1 Installing SWN pumping equipment in place of a worn-out handpump of a different make

1 Remove pump head of old (no longer operational) handpump, as well as underground part (riser pipe, pump rods, cylinder, etc.).

2 In case the pump stand is incompatible with SWN pump heads (different size and spacing of bolts): remove pump stand.

3 If the pump stand is compatible with SWN pump heads, check that the pump stand is well anchored to the pump foundation. If not, check whether the anchor bolts/nuts can be tightened. If this is not the case, remove the old pump stand, e.g. in case of a pump stand that is cast in the foundation, but where the quality of the foundation is insufficient (cracks between pump stand and foundation, pump stand can be moved, etc.).

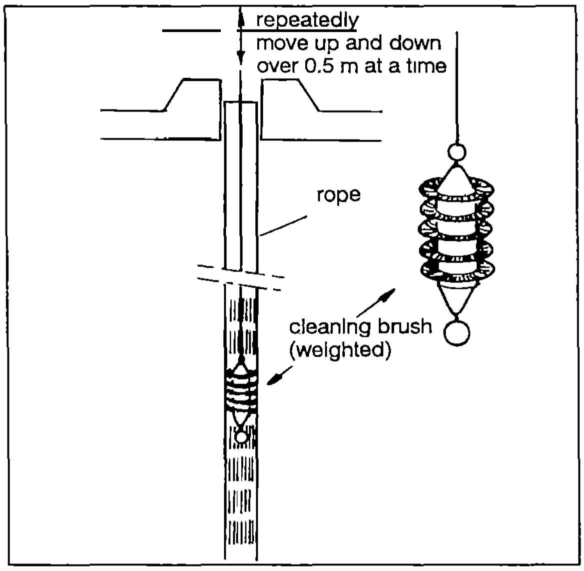
Check whether the quality of the pump stand is sufficient for further use. If so, first remove a sufficiently large part of the pump foundation, then re-install the pump stand and cast a new foundation. Wait at least one week until the concrete has completely set.

4 At the workshop check whether the pump head can be renovated. Open the pump head and check the major parts·
- check that the cylinder wall is smooth inside;
- test the foot valve;
- especially check bearings and pump rod connections;
- replace worn parts if spare parts are available, apply coating and grease where required. If no spare parts are available: replace entire pump head.

5 At the workshop open and check the cylinder:
- check cups and valve seats;
- replace worn parts if spare parts are available;
- if no spare parts are available, replace entire cylinder.

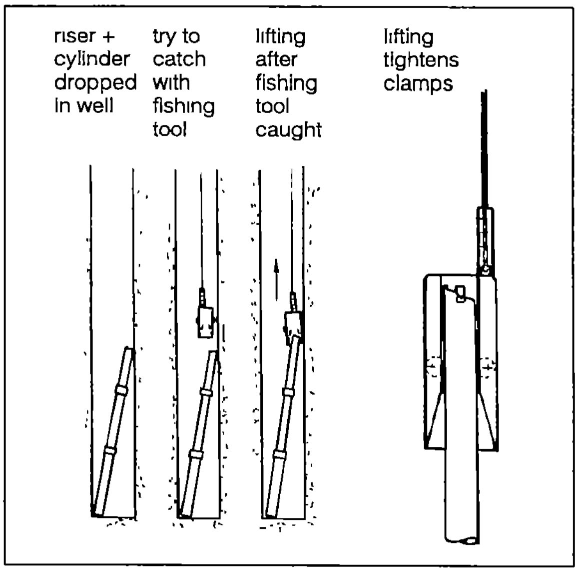
6 Check the riser pipes and pump rods that have been removed. If their size is compatible with SWN pump components, retain the useful components. If not, replace by standard SWN riser/rod combinations

7 If the pump has already been in use for a number of years, the well/borehole needs to be checked and possibly cleaned:
- clean the filter slots of a tubewell with a special hard brush (slots may have become clogged):
  - lower the cleaning brush to the approximate depth where the slots start (estimate or calculate this depth from available data),
  - move the brush up-and-down, say 20 - 30 times, over about 0.5 m at a time;
  - lower the brush 0.5 m and repeat this sequence;
  - continue until the entire (known or estimated) slotted pipe length has been cleaned;



Cleaning borehole

- clean the bottom in case of a shallow well (accumulation of silt may have taken place). This may be done with a bailer, suspended from a rope In case it is known (or suspected) that parts of riser pipes, pump rods, or cylinders have fallen down the borehole or well, these need to be removed first. In tubewells this can only be done with special 'fishing' tools
- add chlorine to the well for disinfection: for each cubic metre of water in the well or borehole (see table below) add one bucket of water to which 100 grammes of bleaching powder has been added, pour into the well and keep it there for at least 12 hours, but preferably for a full day. Operate the pump for a few strokes, so that it is filled with chlorinated water as well.



Use of fishing tools

Calculation of well / borehole volume [m³]

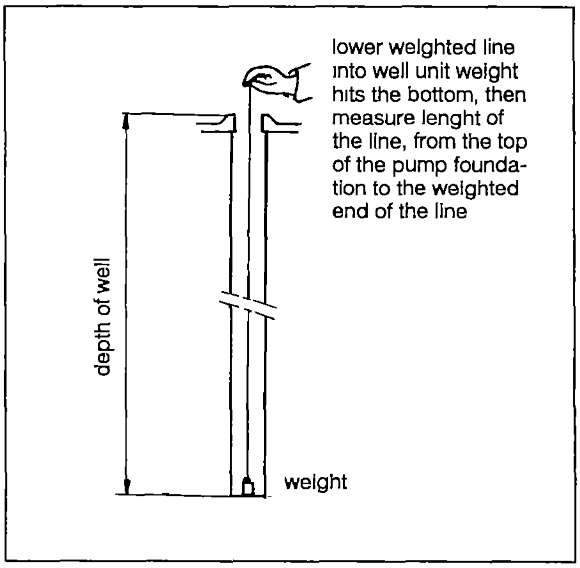
Well diameter [m]:	4"	6"	8"	0.75 m	1 m
Water depth [m]:					
10	0.08	0.18	0.32	4.42	7.85
15	0.12	0.27	0.49	6.63	11.78
20	0.16	0.36	0.65	8.84	15.71
25	0.20	0.46	0.81	11.04	19.63
30	0.24	0.55	0.97	13.25	23.56
35	0.28	0.64	1.13	15.46	27.49
40	0.32	0.73	1.30	17.67	31.42

Do not let people use the well in the meantime. After 12 hours to one day, pump the chlorine solution from the well. This is easiest done once the new handpump has been installed: operate the handpump until the water no longer has a chlorine smell or taste;

8 Measure the depth to the bottom of the cleaned well/borehole:
  - tie a weight of about 0.5 kg to a thin rope and lower this in the well or borehole. In this way the depth of the well/borehole can be found Do not use nylon rope: it stretches and gives an incorrect (low) reading;
  - subtract 1.25 m from the well depth just found; then subtract a multiple of 3 m from the result until the remainder is less than 3 m

(Example: if the measured well depth is 42.80 metres, first subtract 1.25 m; result: 41.55 m. The largest multiple of 3 m that can be subtracted from 41.55 is 39 m (13 x 3 m), leaving a rest of 41.55 - 39 = 2.55 m. From the table below it can be found that for 2.55 m one set of 0.75 m and one set of 1.50 m are required. Adding to this the 13 x 3 m that were subtracted in the first place, the total number of riser/rod sets required is: 1 x 0.75 m+ 1 x 1.50 m + 13 x 3 m, or: a total length of 0.75 + 1.50 + 13 x 3 = 41.25 m.

This means that the cylinder is positioned at 41.80 - 41.25 -1 = 0.55 m above the well bottom).



Determining required riser/rod lengths

Remaining length	1 = 0.75 m	1 = 1.50 m	1 = 2.00 m
0.00 - 0.75 m	-	-	-
0.76 - 1.50 m	1	-	-
1.51 - 2.00 m	-	1	-
2.01 - 2.25 m	-	-	1
2.26 - 2.75 m	1	1	-
2.76 - 3.00 m	1	--	1

- keep in mind that for deep wells/boreholes it may not be necessary to fix the cylinder just above the bottom of the well, and that a position a few metres (say: 2 metres) below the groundwater table may be sufficient (see note on page 27). In such a case, use only 3 m long riser/rod combinations for ease of installation;

9 Neatly lay out all required pump parts on wooden supports, so that threaded ends and bearings remain free from sand. Check that all required parts and tools are available:
  - special pump installation tools (if needed for the pump type to be replaced)
  - SWN pump head mounting brace
  - 3 open ended spanners: 17 mm, 19 mm and 24 mm
  - 2 pipe wrenches, size 1½ - 2½"
  - 2 x T-shaped rod hanger M10
  - 1 x riser clamp for 1½" riser pipes
  - 2 x catcher for Ø 10 mm pump rods
  - a special SWN combination spanner is available; this can be used as a spanner (17, 19 and 30 mm), rod catcher or rod hanger;

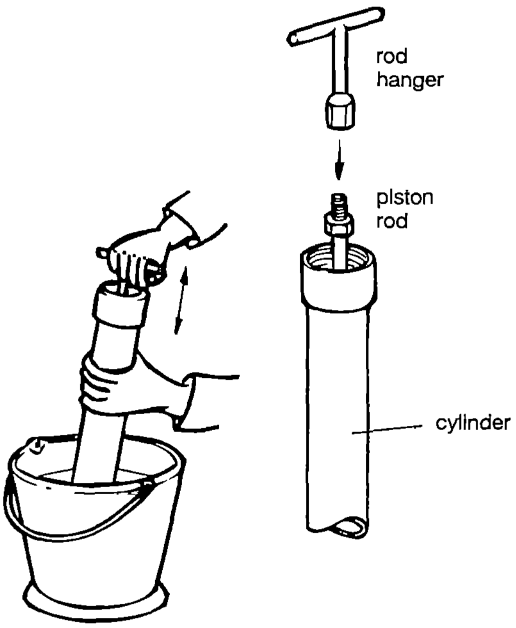
10 Arrange for at least 4 trained staff and some untrained helpers. A tripod is not required: to a depth of even 60 metres installation can be done by hand;

Continue with installation procedure B, as described on page 39.

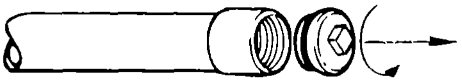
A2 Installing SWN pump on a new well or borehole

Carry out the activities mentioned under A1: items 8 and onwards; then continue with B (page 39).

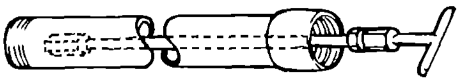
B Installation of below ground level pump components



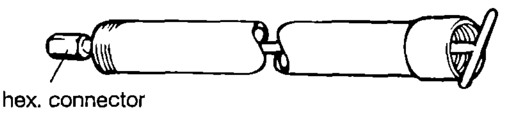
remove riser protectors



after connecting to pump rod,



push rod hanger into riser



1 All pump cylinders have been carefully checked before leaving the factory. However, in case the pump parts have been in store for some time already, it is better to first check the operation of the cylinder:

- fill a bucket with water;
- remove the protective cap from the top of the cylinder;
- connect the T-shaped rod hanger to the top of the pump rod inside the cylinder;
- put the cylinder upright in the bucket and move the piston up and down with the rod hanger;
- if the cylinder is working alright, remove the rod hanger and continue with item B.2; if not: give cylinder to pump workshop or mechanic for checking.

2 After checking the pump cylinder:

- take the first riser/rod combination *(always start with the 3-m combinations first; keep the shorter lengths to the last)*;
- while keeping the riser/rod combination horizontal, remove the thread protectors from the riser ends;
- connect the T-shaped rod hanger to the upper part of the pump rod (the part with a threaded end and check nut). No spanners are required for this: tightening by hand only is sufficient;
- push the rod hanger as far as possible inside the riser, so that the other rod end (with the long connector) protrudes from the riser pipe;
- if necessary, push back the PE protective sleeve, to free the long connector nut.

3 Connect first rod/riser combination to pump cylinder:

- remove the protective caps from the top of the cylinder;

- screw the long rod connector on to the piston rod. *(Use two 17 mm open-ended spanners to secure a tight fit)*;
- push the protective PE sleeve over the connection, as far into the cylinder as possible;
- connect the riser pipe to the top of the cylinder. First screw riser pipe into thread of top cylinder connector by hand, as far as possible, then tighten with pipe wrenches;

Make certain that riser and cylinder top match correctly; do not try to force the riser pipe into the cylinder top.

This could damage the thread!

- it is *not* necessary to use any type of packing between cylinder top and riser pipe. Certainly do *NOT* use glue, solvent cement, or the like!

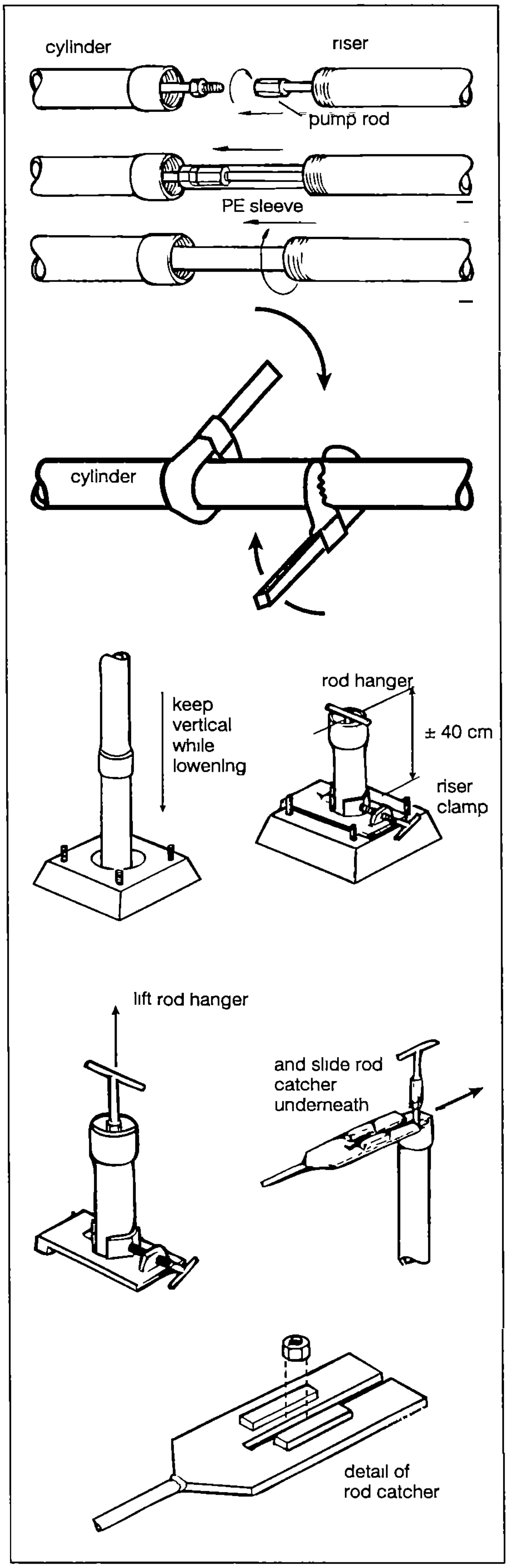
4 Carefully lower cylinder and first riser/rod section into the well/borehole:

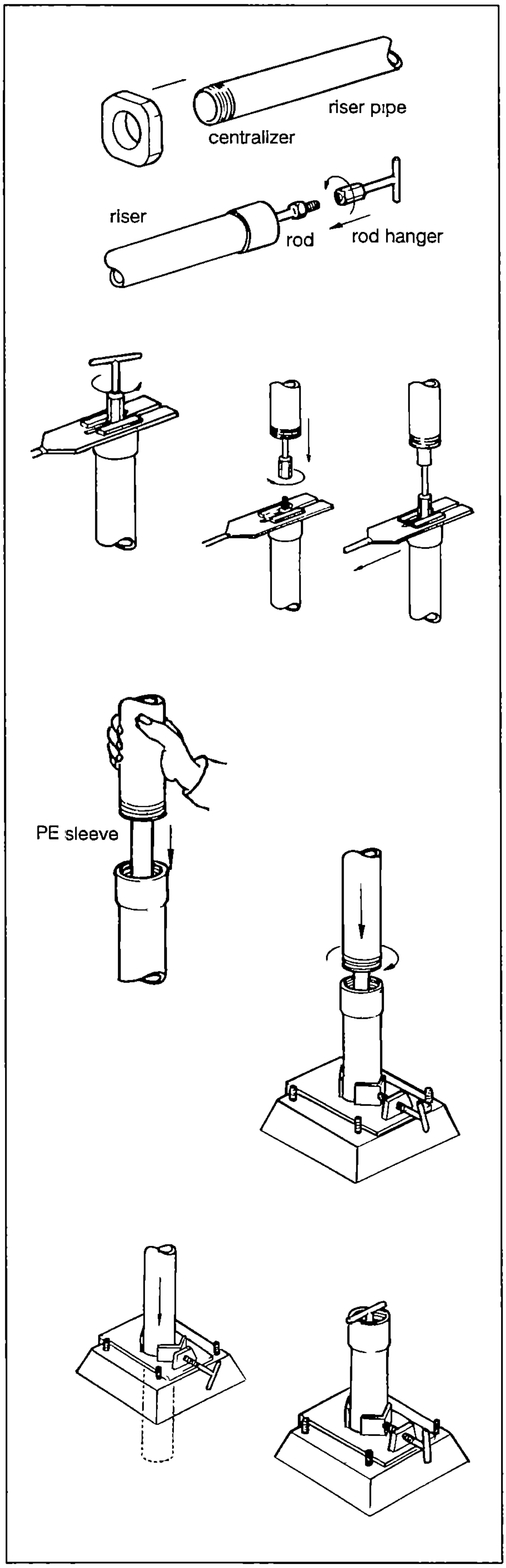
- ensure that the combination is kept vertical while lowering into the well/borehole, to minimize the possibility of damaging cylinder wall or riser pipe;
- mount the riser clamp on the pump foundation;
- fix riser in riser clamp about 40 cm below socket at top of riser.

5 Connect next rod section:

- first lift pump rod hanger until rod catcher can be fitted under check nut at top of pump rod. The rod catcher now rests on top of the riser pipe.

  (The rod catcher has two strips welded along the slit in it, on one side. Keep this side up when the catcher is pushed under the check nut, as the strips will prevent the nut from turning, thus making it easier to tighten the connection between two successive rod sections);
- take the next riser/rod combination;



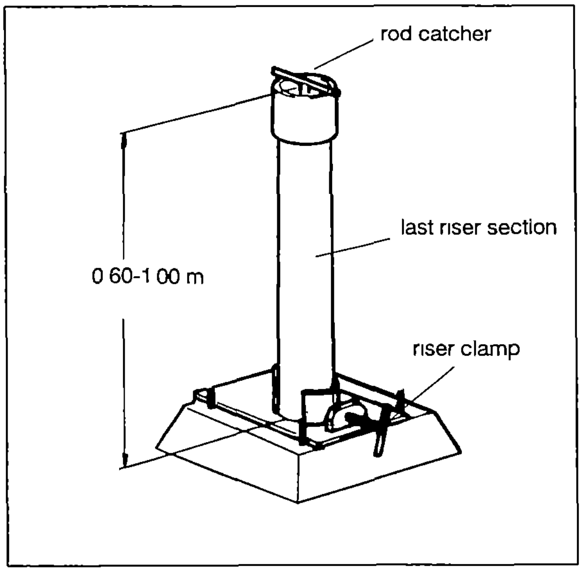


- while keeping the riser/rod combination horizontal, remove the thread protectors from riser and rod ends;
- slide one rubber centralizer over the new riser pipe section *(only in case of small-diameter boreholes and if problems due to snaking or swinging are expected. Use 70 mm square centralizers in Ø 110/103 mm casing/filter pipe; 80 mm square centralizers in Ø 125/117 mm casing/ filter pipe)*;
- connect the second pump rod hanger to the top of the new pump rod;
- remove first pump rod hanger;
- connect the two rod sections, while keeping the latest section of pump rod as vertical as possible *(one 17 mm spanner and the rod catcher are the only tools required)*,
- remove the rod catcher *(pull out sideways)*.
- push the protective PE sleeve of the new pump rod section as far down as possible, until it touches the PE sleeve of the previous section;

6 Connect next riser section:

- keep the riser/rod section vertical and screw the threaded lower end of the new riser pipe section into the connector at the top of the first section;
  - first connect by hand, as far as possible, then tighten with pipe wrenches;
  - while holding the riser, open riser clamp sufficiently to allow riser to be lowered over one section *(be careful not to drop riser/rod assembly in the well/borehole)*;
  - tighten riser clamp about 40 cm below the socket at the top of the new riser section.

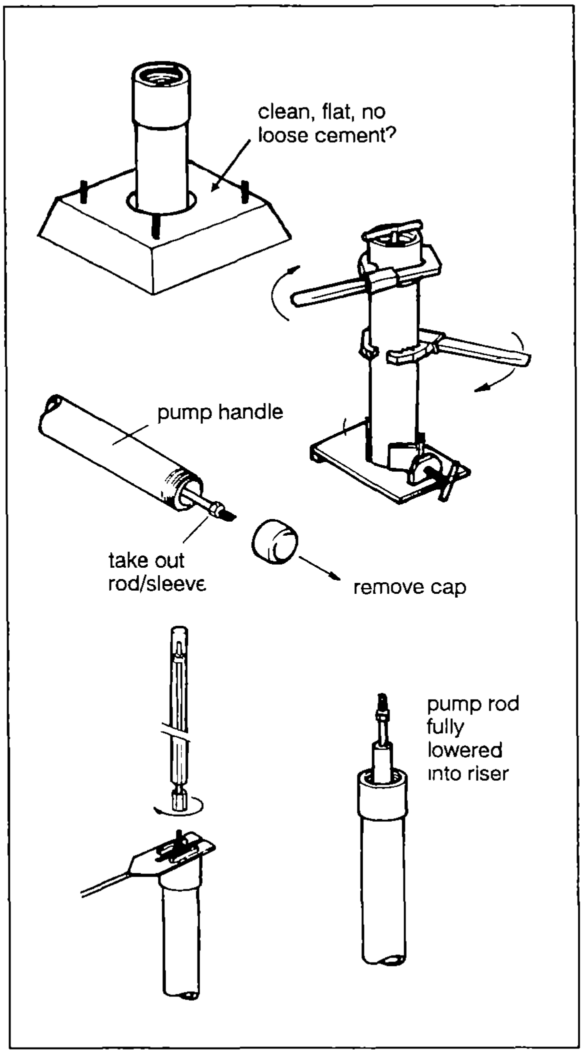
7 Repeat activities 6 and 7 until all remaining riser and rod sections have been connected and lowered into the well or borehole. The final situation is thus:



- last riser pipe fixed in riser clamp. *(This riser section should be fixed so that about 75 cm protrudes above the pump foundation);*
- pump rod puller connected to last pump rod section, with its handle resting on top of the riser connector at the top of the last riser section.

Note: the weight if a riser/rod combination is about 2 kg per metre length. For a 40 m deep well the total weight is thus about 80 kg, which can be handled by two men without special tools.

C Installation of pump stand and pump head



1 Before lowering the cylinder and first riser/rod combination, first check that the rubber base flap which is glued to the pump base plate, is clean, and free of sand and the like:

   - check that the surface of the pump foundation is clean and flat: no loose cement or concrete spots;
   - in case the pump foundation is not entirely flat, use a pump stand with 15 mm foam rubber pad (rather than 6 mm soft rubber pad) underneath.

2 Connect pump rod extension part:

   - unscrew PVC connector from top-most riser pipe section *(two pipe wrenches are needed for this).* Slide rod catcher under lock nut and remove rod hanger and PVC connector;
   - remove the special pump rod extension part (0.75 m long) from the pump handle *(remove cap from end of pump handle and take out rod/sleeve assembly)*, and connect to the top of the last pump rod section; slide the PE sleeve over the rod, and as far down as possible;
   - remove rod catcher and lower the pump rod as far as possible *(a part will still protrude from the last riser section).*

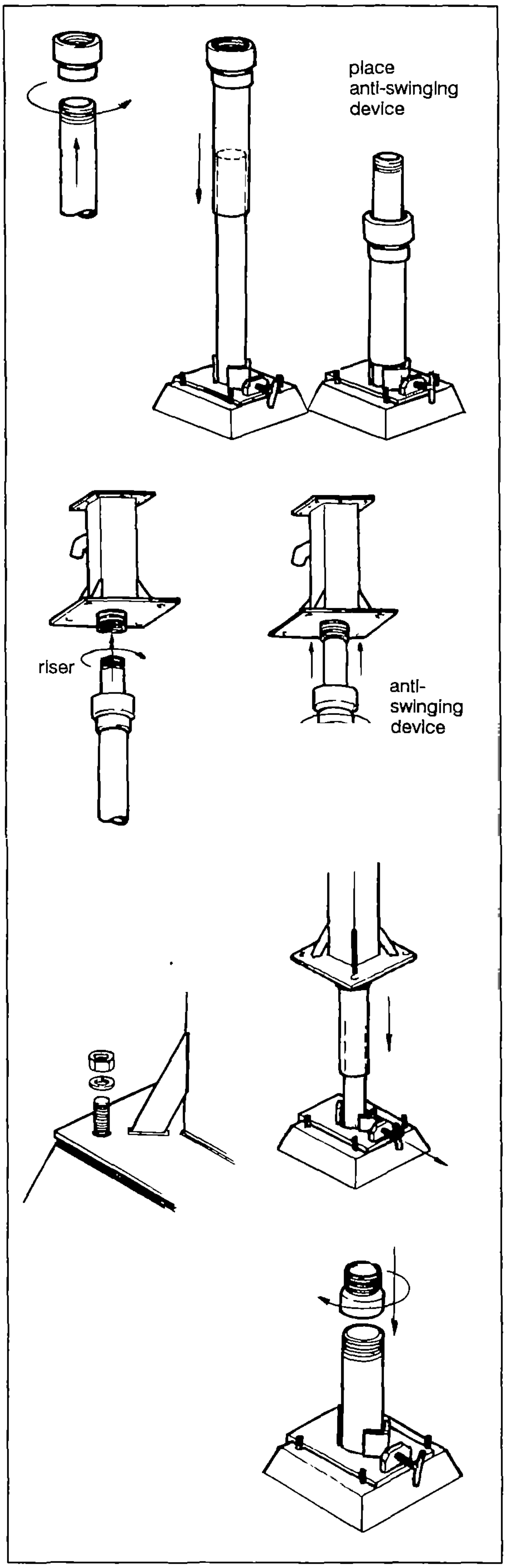
3 Connect riser pipe to connector underneath pump stand and fix pump stand to pump foundation.. The procedure is different for pump stands with and without anti-swinging device:

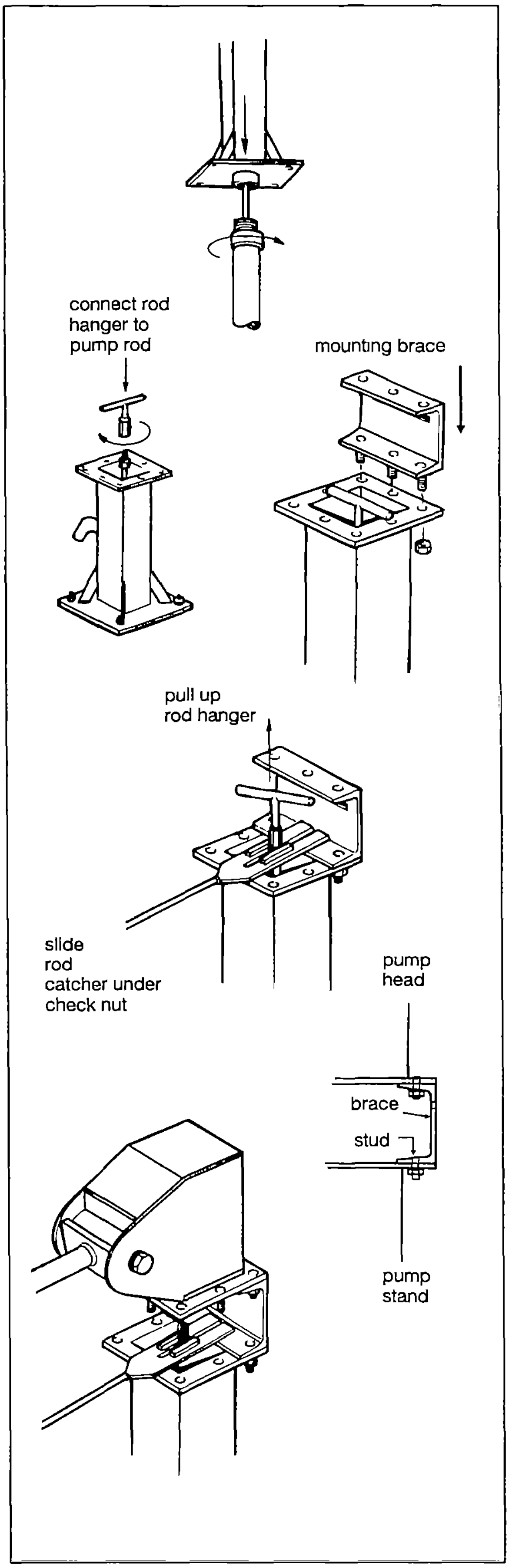
***with anti-swinging device** (used in principle in larger-diameter wells only; see page 21)*:

- slacken riser clamp, lift riser pipe and fix again in such a way that about 75 cm protrudes above the pump foundation;
- screw threaded end of 50 m long Ø 2" GI or PVC pipe into 2½" - 2" reducing socket. Fix tightly with pipe wrenches;
- slide the pipe (reducing socket at its top) over the riser pipe *(pipe rests on riser clamp);*
- have two helpers lift the pump stand over the riser pipe and carefully screw the top of the riser pipe into the connector at the bottom of the pump footplate *(do this carefully, as the thread of the PVC riser may be damaged otherwise. Tighten connection with a pipe wrench)*;
- lift the anti-swinging pipe and screw on to the outside of the connector at the bottom of the footplate. Tighten well, using a pipe wrench;
- while lifting pump stand, slacken and remove riser clamp *(be careful, as entire weight of pump stand, riser and rods now has to be supported).*
  At this stage it is very cumbersome to have to correct misalignment of the anchor bolts. Therefore, check the anchor bolts *before* starting installation (see "General installation procedures" on page 34);
- carefully lower pump stand onto pump foundation *(keep spout in the correct direction, and keep holes in pump footplate aligned with anchor bolts);*
- place GI rings over protruding ends of footplate anchor bolts, and tighten nuts with 24 mm spanner.

without anti-swinging device:

- screw 1½" GI adapter socket (from internal to external thread) on to top of





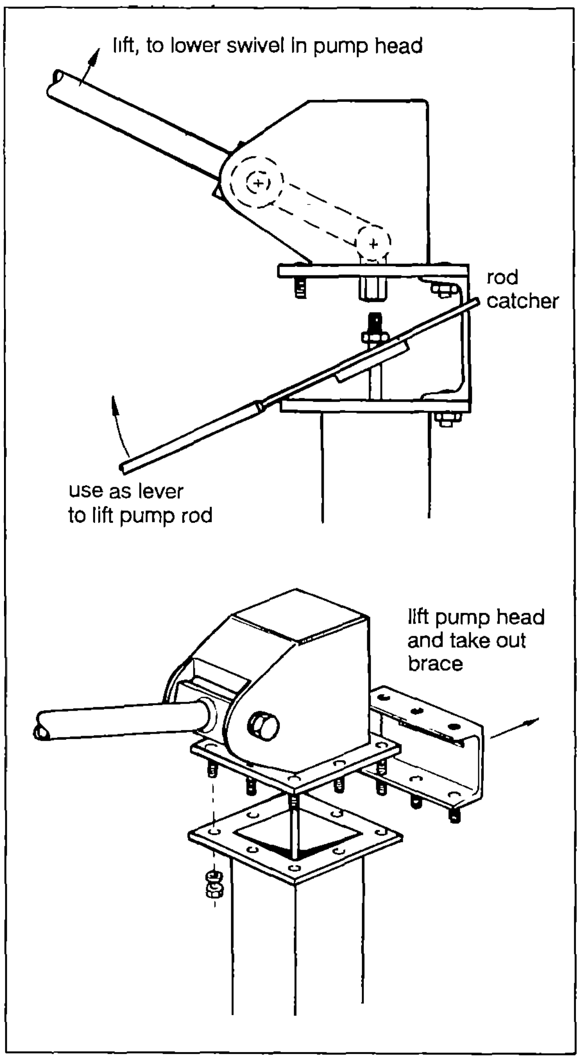
last riser pipe section;

- lift pump stand over riser pipe;
- carefully screw GI adapter socket into bottom connector of pump stand. Tighten well by means of a pipe wrench;
- while lifting pump stand, slacken and remove riser clamp *(be careful, as entire weight of pump stand, riser and rods now has to be lifted)*;
- carefully lower pump stand onto pump foundation *(take care to keep spout in the correct direction, and to keep holes in pump footplate aligned with anchor bolts);*
- place GI rings over protruding ends of footplate anchor bolts, and tighten nuts.

4 Install pump head. The procedure mentioned is the same for all standard SWN handpumps: SWN 80, 81 or 90:

- connect T-shaped rod hanger to top of pump rod *(this is just below the top of the pump stand)*;
- fix mounting brace on top of pump stand *(feed studs at underside of brace through holes in pump stand, so that open part of brace faces the mechanic, and fix with nuts, using open-ended spanner size 19)*;
- pull up rod hanger, slide rod catcher under check nut, and into slit in the back of the mounting brace *(in this way the rod catcher can be used as a lever, for easier lifting of the entire cylinder/riser/ rod assembly. In this case the catcher must be* ***upside-down****, as the check nut must be able to turn freely)*;
- place the pump head on top of the mounting brace: feed studs at underside of pump head through holes in brace, so that pump head is positioned exactly over pump stand;
  (at this stage the direction in which the head is facing is not important, as it can easily be changed after the pump rod has been connected to the pump head);

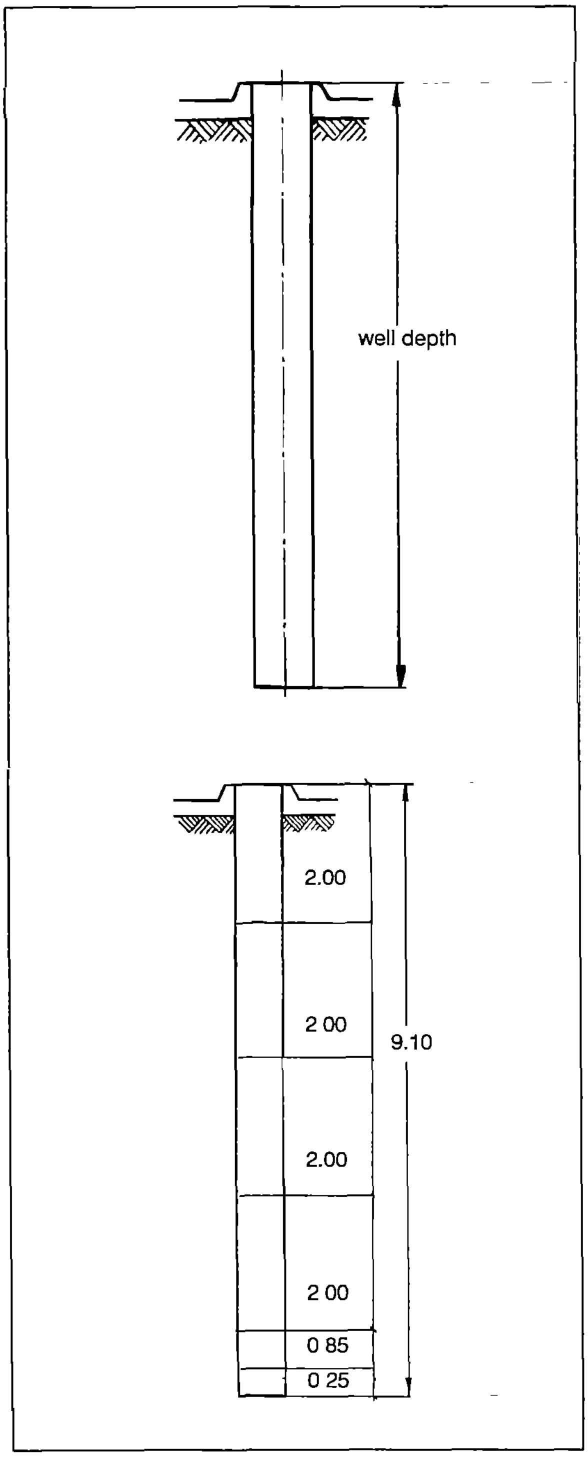
- connect the top of the pump rod to the swivel connector in the pump head:
  - lift the top of the pump rod by using the rod catcher as a lever;
  - lower the swivel connector by pushing the pump handle upwards;
  - connect pump rod to swivel connector until at least two threads have fully engaged;
  - remove rod catcher;
  - fully tighten connection, using two 17 mm open ended spanners;
- carefully lift pump head and take out mounting brace;
  (Be careful as the full weight of the pump rods as well as the pump head must be supported. Arrange for at least two helpers. Remove nuts from studs at bottom of pump head and brace before lifting brace and taking it out);
- lower pump head on pump stand and fasten with nuts.
  (Check that pump head is facing the correct way. Depending on local preference the spout of the pump may be facing away from the handle, or the two may be at right angles to each other. Placing spout and handle at right angles makes it possible for a single person to pump and drink water from the spout. Unlike several other makes of pumps, the square flange of the SWN pump heads gives full flexibility in this matter. Firmly tighten the nuts, using open ended spanner size 19).



D Installation of Afya direct action pump

1 First carry out the preparatory activities mentioned on page 34 *(General installation procedures)*;

2 Measure the depth from the top of the pump foundation to the bottom of the well or borehole:



- tie a weight of about 0.5 kg to a thin rope and lower this into the well/ borehole. In this way determine its depth;
- subtract 25 cm from the depth just found and subtract the largest possible multiple of 2 metres. This is equal to the total number of 2-m lengths that can be lowered into the well or borehole. Since the cylinder also has a length of 2 m, the actual number of riser pipes is **one less** than the number just found.

  The difference between the well depth minus 25 cm, and the total length of the 2-m sections just calculated, determines whether it is useful to connect a length of suction pipe underneath the cylinder: if the difference is larger than 50 cm, connect a suction pipe; if smaller than 50 cm: no suction pipe necessary. The suction pipe must be cut off at length on site: its length must be such that after installation its lower end is not less than 25 cm over the bottom of the well or borehole.

Example:

A. Borehole with depth of 9.10 metres

Subtract 0.25 m: resulting length = 8.85 m. This means that 4 sections of 2 m each can be lowered into the borehole (1 cylinder and 3 riser pipe sections).

The difference between the total length of cylinder + riser sections (4 x 2 = 8 m) and the calculated required length of 8.85 m, is 0.85 m. This is larger than 0.50 m, so it is useful to connect a piece of suction pipe underneath the cylinder. Its length may be up to 0.85 m. If longer, the distance between the lower end of the suction pipe and the borehole bottom would become less than 0.25 m, which is not recommended.

B. Well with depth of 6.50 metres.

Subtract 0.25 m; resulting length = 6.25 m. This means that 3 sections of 2 m each can be lowered into the well (1 cylinder and 2 riser sections).

The difference between the total length of cylinder + risers (6 m) and the length just calculated (6.25 m) is less than 50 cm, so no suction pipe is recommended. The underground part of the pump thus consists of 2 riser pipes of 2 m each, with a 2-m long cylinder underneath. The lower end of the cylinder is therefore positioned at 6 m below ground level, or: 50 cm over the bottom of the well.

3 Neatly lay out all required pump parts, preferably on wooden supports or on a tarpaulin, to keep threaded ends free from sand an dirt. Check that the following tools are available:

- 2 x T-shaped rod hanger M16
- 2 x pipe wrench 2"
- open ended spanner 24 mm
- riser catcher
- simple hacksaw for cutting riser pipe

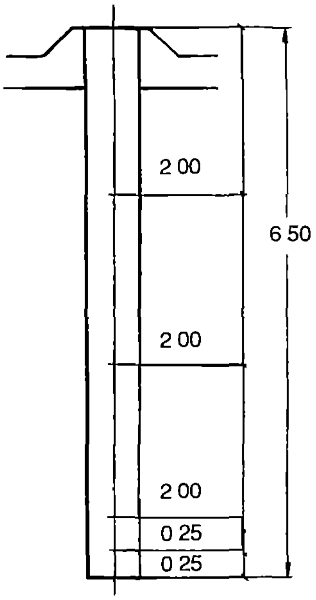
4 Arrange for four helpers. Neither a tripod nor special clamps are required: for all applications of *Afya* direct action pumps (well depth up to 10 m) the riser/rod combinations and the cylinder can easily be handled by hand only;

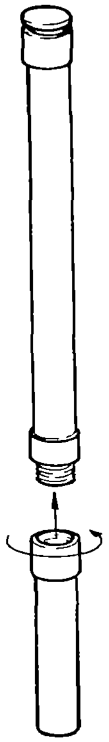
5 Attach suction pipe to bottom connector of cylinder:

- take a length of suction pipe and cut off a length as calculated above for the suction pipe *(take the end with the connector; cut pipe at right angles)*;
- screw suction pipe over bottom connector of cylinder, and tighten as fast as is possible, using pipe wrenches;

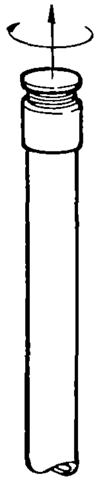
6 Remove the protective cap from the top of the cylinder, and connect first rod hanger to pump rod section inside cylinder;

7 Lower cylinder with suction pipe into well *(ensure that the combination is kept vertical when lowering into the well, to avoid damage; slide the riser catcher underneath the connector at the top of the cylinder, and let it rest on the pump foundation);*

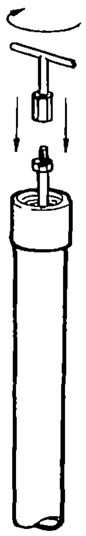




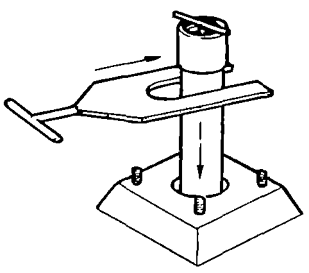
connect suction pipe



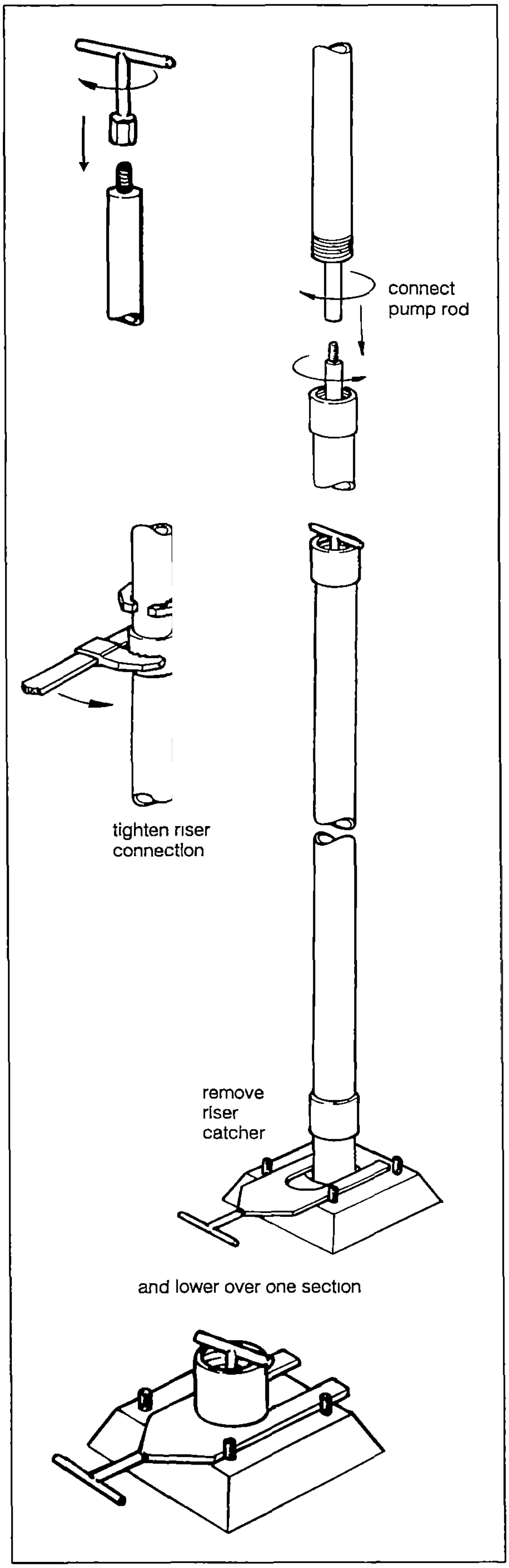
remove top cap from cylinder



attach rod hanger



rest riser on catcher



8 Connect next section of riser and pump rod:

- connect the second T-shaped rod hanger to the upper part of the pump rod (the part with the steel connector). This can be done by hand;
- keep the new section vertical over the well, and have one helper lift the riser pipe section;
- another helper pulls up the first rod hanger and removes it while keeping the pump rod in his other hand;
- the two pump rod sections are joined together and fastened with the use of pipe wrenches *(first tighten by hand as far as possible)*;
- lower the new riser section onto the connector at the top of the cylinder, and connect *(make the connection by hand, as far as possible; then tighten with pipe wrenches)*;
- remove the riser catcher, lower the riser over one pipe length, and place the riser catcher again;

9 Repeat activity 8 until all remaining riser and rod sections have been connected and lowered into the well. The final situation is thus:

- last riser pipe resting on riser catcher (with the connector at its top);
- pump rod puller connected to last pump rod section, with its handle resting on top of the riser connector.

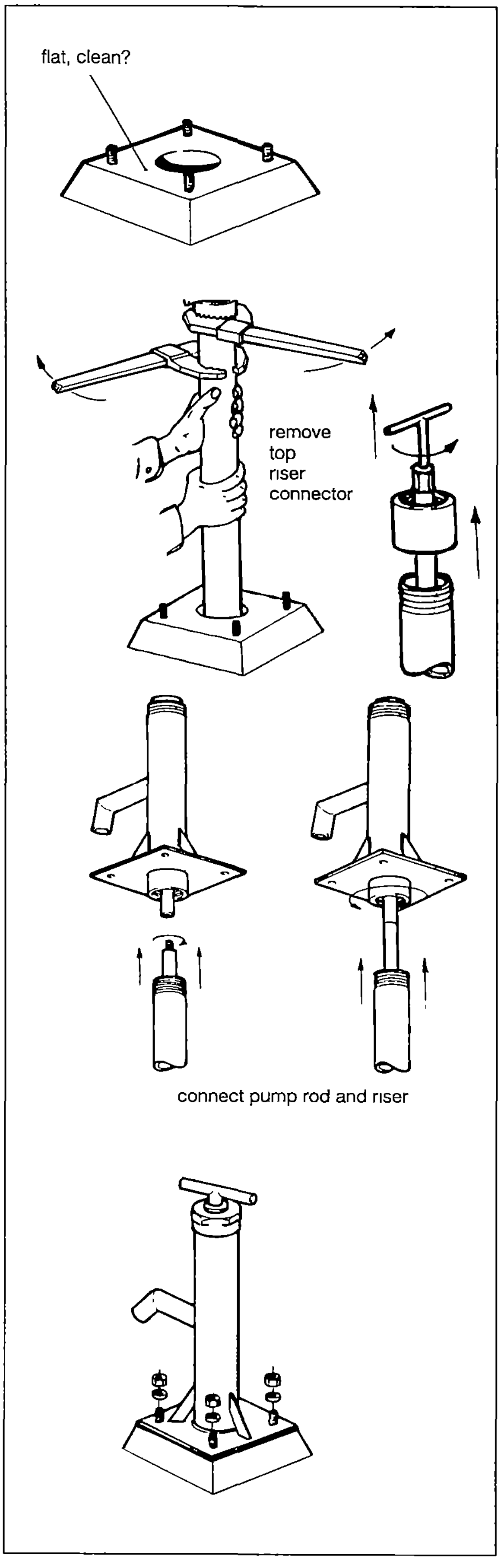
Note· the weight of even 10 m of cylinder and riser/rod sections can easily be held by one man. For that reason in fact no riser catcher would be required. Taken the low cost of such catcher and the much easier installation, the installation is described here for the option with riser catcher, however.

10 Connect last riser and rod to pump head:

- first check that the rubber base flap that is glued to the pump foundation is clean, and free of sand and the like;
- check that the surface of the pump foundation is clean and flat: no loose cement or concrete spots;
- remove the PVC connector from the topmost riser pipe section: first unscrew the PVC connector *(two pipe wrenches are needed for this)*, then lift connector and rod hanger, grasp pump rod between riser pipe and PVC connector, unscrew rod hanger and remove PVC connector; re-attach rod hanger;
- remove riser catcher;
- hold the pump stand/pump head over the well head;
- remove the rod hanger from the last section of pump rod *(take care that the rod does not drop in the riser pipe)*;
- push down the pump handle/pump rod in the pump stand/pump head, and connect to last pump rod section *(connect by hand first; then tighten with pipe wrenches)*;
- screw top of riser pipe into connector under pump footplate *(first connect by hand; then tighten with pipe wrenches).*

11 Mount pump stand on foundation:

- carefully lower pump stand on to pump foundation *(check that spout is facing in the correct direction, and keep holes in pump footplate aligned with anchor bolts)*;
- in case one of the anchor bolts is out of plumb, first put one or two nuts on it, then adjust position of bolt by gently hammering against the nut(s). *Never apply unnecessary force!*
- place GI rings over protruding ends of footplate anchor bolts, and tighten nuts with 24 mm spanner.



MAINTENANCE

How to deal with maintenance

Why is it that most handpumps in Africa appear to be out of order, and what can be done about it?

☐ **After breaking down, they are not removed!**

Imaging that the same would be done with cars: all towns and villages of Africa would be choked with car wrecks. Yet, this is not the case. Why?

- the car has *an owner*
- it is *private property*
- any rest value is capitalized: the car wreck is sold, and its parts used to repair other cars: *profit for the owner*

In those cases that the cars are *not* privately owned, as with Public Works Departments or provincial or regional water agencies, their yards indeed often resemble a junk yard, as car wrecks are not (allowed to be) removed.

Being private property, with the potential to bring the owner financial gain, thus appears to be essential for ensuring maintenance, for cars as much as for handpumps

☐ **Are the handpumps really beyond repair?**

If the check nut on the main bearing shaft of a handpump works itself loose and is lost or stolen (nobody is interested or takes care), the bolt drops from the pump, the handle can no longer be operated, and the handpump stops functioning It is abandoned, nobody considers it important any longer, any remaining useful parts (bolts and nuts) are taken away and the handpump becomes scrap *(a familiar scenario in many regions in Africa)*

Because no operational maintenance system was set up, a part worth only $ 0.10 that is lost, thus causes the full breakdown (read: capital destruction) of a structure costing as much as $ 4000!

☐ **Why are they not repaired?**

- the project which installed the handpump in the first place, was terminated years ago; the donor has left the country, or is at least no longer involved in the project ;
- it was agreed that the provincial or regional water agency would arrange maintenance centrally, but scarcity of funds renders this impossible, while political pressure makes the agency concentrate first and foremost on the piped water supplies that serve the electorate in the cities;
- no local handpump caretaker has been appointed or elected;
- even if a caretaker is available, he or she does not have the required spare parts, nor the money to arrange for those spares;
- etc.

Under such conditions, what is the practical use of the VLOM (village-level operation and maintenance) concept?

For the VLOM approach to work

- maintenance of the handpump must have been *arranged,*
- the village / community / users must be *involved,* and
- *spare parts and tools* must be readily available, in the village or community.

But:
- will the people *remain* involved? (paying caretakers often costs a multiple of the original construction/installation costs)
- will there *continue* to be a stock of spares? (who pays for them? who prevents pilferage or unauthorized sale?)
- will the people *continue* to be willing to contribute, in cash or in kind?

Do not have the illusion that this will be so merely because the government, authority or project says so. Only if at least one person really benefits from keeping the handpump operational, and preferably benefits financially, maintenance can be reasonably ensured. If nobody is really interested, maintenance will never take off, and the money is wasted. Therefore: make the pump and well as 'maintenance-free' as possible

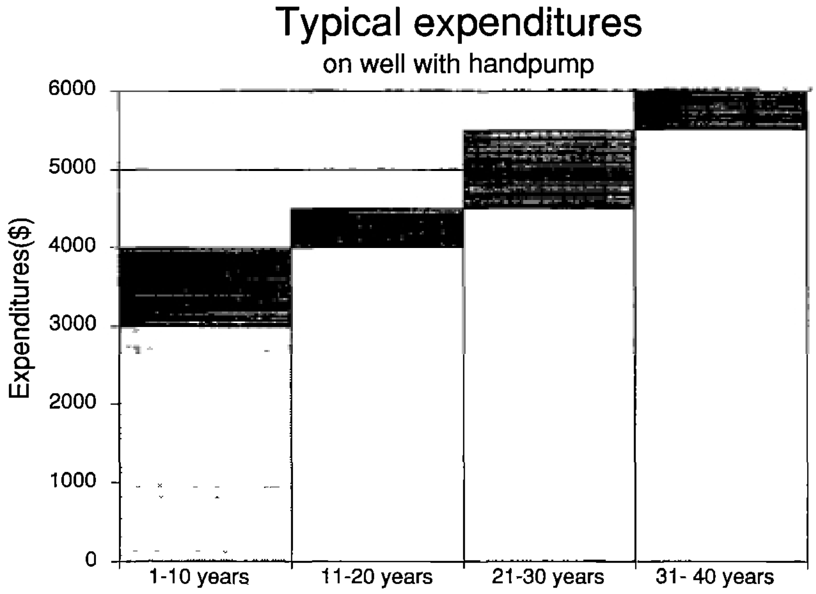
Why is maintenance necessary? Why does the handpump not last forever?

A handpump-based water supply system consists of:

- a dug or drilled well or borehole that - if well constructed - can last for 30-50 years with minimal maintenance;
- a steel structure (handpump), consisting of housing, pump stand, bolts and nuts, that - provided its parts are well protected against corrosion (hot-dip galvanized, coated with bitumen, etc.), and this protection is renewed every 5-10 years - should remain operational for about 20 years;
- wearing parts, such as bearings, pins, bushes, risers/rods, cylinder piston assembly, valves, rubbers, etc., which should be designed and manufactured in such a way as to remain operational for at least 10 years.

During its technical lifetime of, say, 40 years, for a typical well or borehole with handpump the following costs would be made (excluding overhead, platform maintenance and local costs):

Year	Component	Cost ($)
at the start:	well or borehole:	3,000
	handpump:	1,000
after 10 years:	wearing parts:	500
after 20 years:	new pump set:	1,000
after 30 years:	wearing parts:	500
total during 40 years:		6,000



Ownership

To keep a handpump in working condition *someone* must be responsible! If this has not been arranged (many handpumps were simply 'dumped' by donor-assisted projects) the handpumps will be out of order in a very short time, as experience shows, *a waste of money*.

- if no organization such as a church, mission post, organized group of villagers, water committee, or the like, can be involved, then an individual must be found to take care of the handpump. If nobody is interested, it is better to forget the idea of installing a handpump, and to look elsewhere where people would be interested in a good water supply, and willing to put effort in its upkeep *(the same donor that would install a handpump without arranging maintenance, would not even think about giving a car to a village, unless there would be a trained driver, garage or workshop and money for buying petrol and carry out repairs!)*;
- *ownership* means supervision and regular *checking* of the pump operation; this checking will show that at times *repair* is necessary, and for repairs both *expertise* and *spare parts* are required;
- for the pump to really be a VLOM pump, it should be as common as a bicycle: everywhere in the world bicycles are repaired, also in the villages. However, what would remain of the concept of, for instance, a VLOM bicycle, if there would be no money to arrange for a new tire, or even for patches to repair a punctured tire? Consequently, the VLOM concept is a relative one: what is really VLOM at one place, is not necessarily VLOM at another place as well!

How to get involved handpump owners?

In principle, there must be an element of profit to get owners, co-financiers, investors, etc. involved in handpump maintenance. The 'profit' element may be in the form of:

- sale of water, e.g. for cattle watering;
- produce from a private garden, through garden watering;
- sale of water for drinking water;
- increased status in the community.

It may be sufficient to get people involved, if there is a *real need* for a new water source, e.g. when:

- there is no alternative;
- a local source is needed for an institution that has the means to pay for it, such as:
  - business organization;
  - governmental institution;
  - mission or church;
  - hospital;
  - school.

Generally, an individual farmer or villager will not be in a position to invest in a water source of his own. In practice, therefore, the government, donor organization or NGO (church, mission, philanthropic organization, etc.) will remain the main provider of handpump water supplies, even though it may not necessarily be counted upon as the one who will take care of maintenance.

How to promote handpumps being owned by private persons:

- appoint a main dealer, preferably an existing organization dealing in agricultural mechanical equipment, with sub-dealers in the various regions (one dealer per country);
- also arrange that the main dealer:
  - is allowed to import handpumps;
  - has a stock of pumps and spare parts;
  - has his own pump manufacturing facilities, where this is feasible.

Pitfalls for local production:

Experience in developing countries has shown that there are certain practical problems related to local manufacturing which cannot be easily overcome. Apart from the fact that the required skills, know-how, theoretical knowledge and experience that are required for local production of handpump components may not be available, additional problems faced are:

- in most African countries both the raw materials (steel, PVC, nylon, etc.), tools, accessories (welding electrodes, crating, etc.), if available at all, are often of *inferior quality* and *more expensive* than in western Europe;
- public utilities such as power supply, telephone, telefax, road network, communication facilities, etc. are often less developed, which renders management of production facilities less efficient and production less cost effective;
- marketing in third world countries is often very difficult, if not impossible;
- keeping local production operational and successful, requires strict quality control, a concept that is often unknown in developing countries.

Consequently, even with lower wage levels a locally made handpump may easily be more expensive, while being of inferior quality. For rural water supply, the more so in the case of larger-scale projects, the community cannot afford to invest unnecessarily, and certainly not in inferior handpumps. Choosing for the tried-and-tested, durable and high-quality option should therefore have priority over local production for the sake of local production only.

Maintenance in practice

Unfortunately, preventive maintenance of handpumps is the exception rather than the rule. Maintenance is thus normally *breakdown maintenance*, carried out after the handpump has been reported out of order. Such maintenance, especially if a trained mechanic has to come from outside the village, is *expensive*. Hence it is better to prevent repairs as much as possible. Since preventive maintenance apparently is no realistic option, ***the handpump design must build in sufficient guarantees that the pump will last long enough (say: 10 years) without maintenance!***
In the field the most frequently observed problems with handpumps are:

- *corroded GI riser pipes*: even the best hot-dip galvanized pipes do not last long in corrosive environments, resulting in leaking risers (which render the pumps unusable) and in the worst case in riser pipes breaking off and falling into the borehole or well;
- *leaking valves in the pump cylinder*, often because leather cup washers are used, which wear out too quickly. Using leather washers also introduces the risk that inferior quality leather is used for manufacturing them, thereby further reducing the effective lifetime of the washer. As in most cases the entire riser/rod assembly needs to be dismantled for replacing the washers, the galvanization of the risers is easily and repeatedly damaged, further accelerating the decay of the below ground parts of the pump

For several pump types the so-called *open-top cylinder* option has been promoted for reducing maintenance costs. In this option the internal diameter of the riser pipe is (at least) the same as that of the cylinder Although this makes it possible to withdraw the pump rod and piston assembly without having to dismantle the riser pipe, it is not the solution it might appear to be.

- with good-quality piston and valve seals, the lifetime of the cylinder components is so long that the considerable additional investment for the larger-diameter riser pipe (2-4" diameter rather than 1½") is not warranted at all;
- if GI pipe is used for the riser pipe, the pipe is corroded and fails even before there would be any problem with the cylinder, thus defeating the very purpose of the open-top-cylinder;
- in case of problems with extracting the cylinder foot valve, or when the riser-cylinder connection is leaking, the entire string of riser pipe and pump rod would still have to be disassembled Because of the much heavier riser pipes, this is far from easy, requiring the use

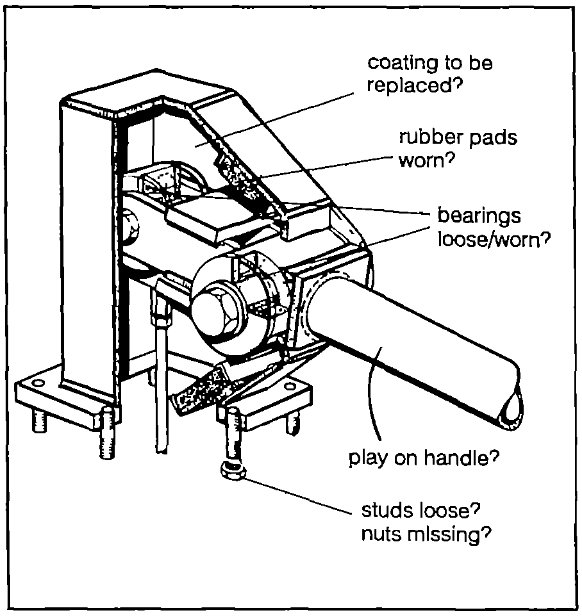
of a tripod and more helpers, thus being *more expensive*. Because the riser pipe sections again need to be dismantled, the galvanization is damaged once more by the beaks of the pipe wrenches.

In short, this is not a solution at all! It is better to install a good-quality cylinder, which does not require the frequent replacement of valves and cup seals, on a corrosion-proof riser/pump rod string, even if the diameter of the riser would make it necessary to dismantle the underground part of the pump for the repair or exchange of a cylinder component. As such repair or exchange is hardly ever necessary, there is virtually no need for disassembling the riser pipe, so that this solution is both more user-friendly and much more cost-effective.

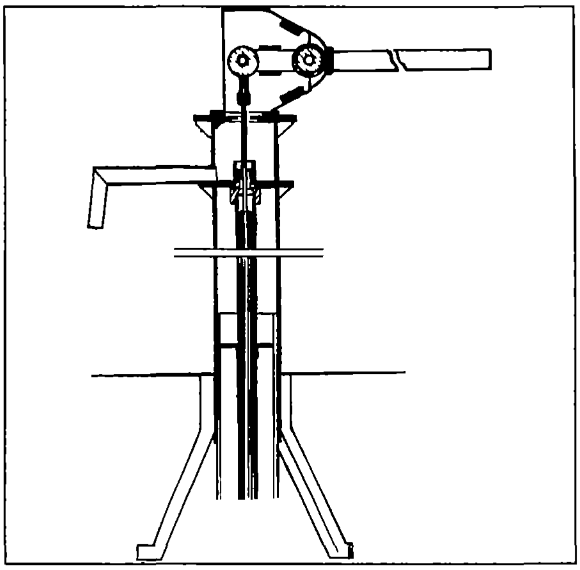
Handpump maintenance

For corrective maintenance or repair of existing worn-out handpumps of whatever make, do the following:

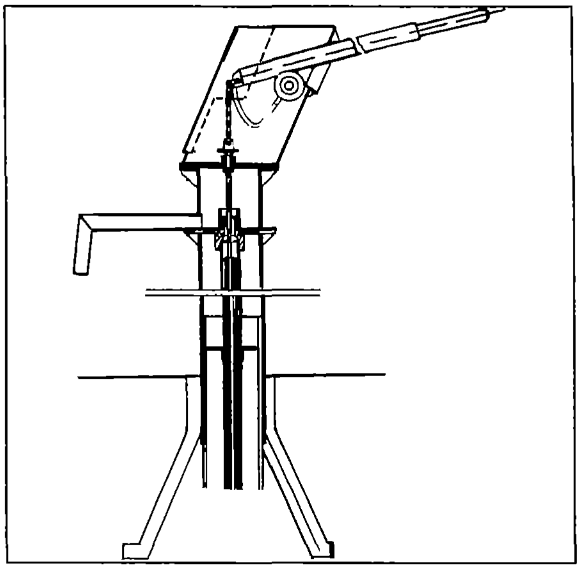
1. Put some oil (preferably penetrating oil) on all nuts visible at the connection between pump head and pump stand, and on those of the anchor bolts. Allow for some time for the penetrating oil to work;
2. Loosen nuts that connect pump head and pump stand (for SWN pumps: use spanner size 19 to remove 8 nuts from the studs in the pump head flange);
3. Carefully lift pump head from pump stand;
   - for SWN pump heads:
     - slide pump rod catcher underneath check nut (flat side up, so that nut can turn freely);
     - disconnect pump rod from swivel (use 2 spanners size 17) and install rod catcher;
     - take off pump head;
     - connect rod hanger to top of pump rod, and lower rod in the pump stand;
   - for non-SWN pump heads:
     - disconnect pump rod from chain or other connection to pump head. Be careful not to drop pump rod into riser. Use catcher or wrenches where necessary;
     - take off pump head;
4. Check inside of pump head for wear, discolourations, dirt, etc.
   - if the pump head has been in use for several years: take it to the workshop for:
     - thorough checking;
     - cleaning;
     - replacement of worn parts, such as bearings;
     - applying new coating or paint;
   - if the pump head/handle is of inferior quality, or if the bearing assembly has been constructed in such a way that it needs frequent replacement (e.g. too thin journal bearings have been used, or other bearing types that need to be replaced regularly), the pump head is not suitable for use in the field:
     - replace the entire pump head by an SWN pump head. Special adapters are available for mounting SWN pump heads on pump stands of most other makes of handpumps;



Pump head inspection points



Adapter for mounting SWN pump head on other make pump stand



Adapter for installing SWN riser/rod construction in other make pumpstand

5 Remove (bolts and) nuts from connection between water tank and pump stand, where applicable, and take out water tank;

- where applicable, disconnect riser pipe from water tank, taking care not to drop riser into borehole or well. Use riser clamp or wrenches where required;
- take off water tank, take to workshop and check for cracks, leakage, etc.:
  - weld any cracks shut;
  - apply at least 2 layers of coating to the outside;
  - apply a suitable bituminous coating to the inside *(since water will be in contact with the inside of the water tank, be careful to use a bituminous coating that has been officially accepted for use in structures containing drinking water; be especially careful not to use a coating that might contain chemical substances that are injurious to health!)*;

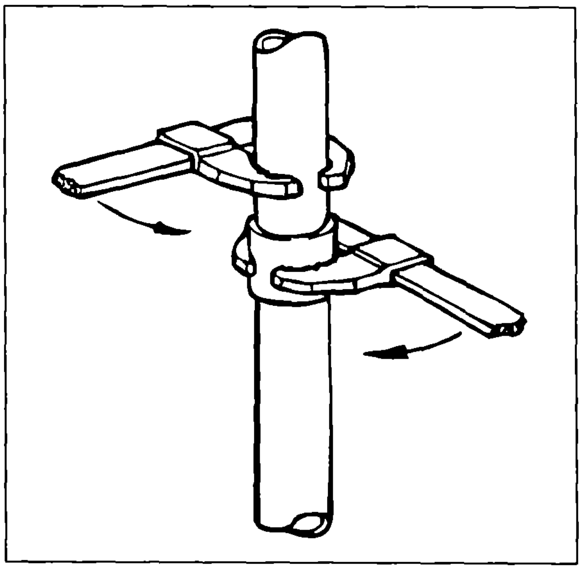
6 Remove nuts from the anchor bolts and remove pump stand:

- for SWN pumps:
  - use spanner size 24 to remove anchor bolt nuts. Be careful to keep nuts for future use;
  - carefully lift pump stand and fix riser clamp to riser, about 40 cm below pump footplate *(in case an anti-swinging pipe is attached to the footplate, raise pump stand so that bottom end of anti-swinging pipe is at least 10 cm above pump foundation; then fix riser clamp to riser)*,
  - using 2 pipe wrenches, disconnect riser from connector underneath footplate *(where applicable the anti-swinging pipe must first be disconnected. Lower this pipe on to the riser clamp, then disconnect the riser from the footplate)*;
  - using the rod hanger, lift the pump rod and slide a rod catcher under the rod connection (from now on use the catcher with the 2 strips facing upward);
  - using the rod catcher and a spanner size 17, disconnect the pump rod from the special rod length used inside the pump stand. Remove the rod hanger from that piece of rod;
- for non-SWN pumps (where applicable):
  - remove the pump stand in manner similar to that described above for SWN pumps. *(Take care not to drop the riser into the well or borehole. Use clamps or pipe wrenches wherever applicable)*;
- for all types of pumps:
  - check for visible signs of wear or leakage. If repairs can be done on site, do so. If not,

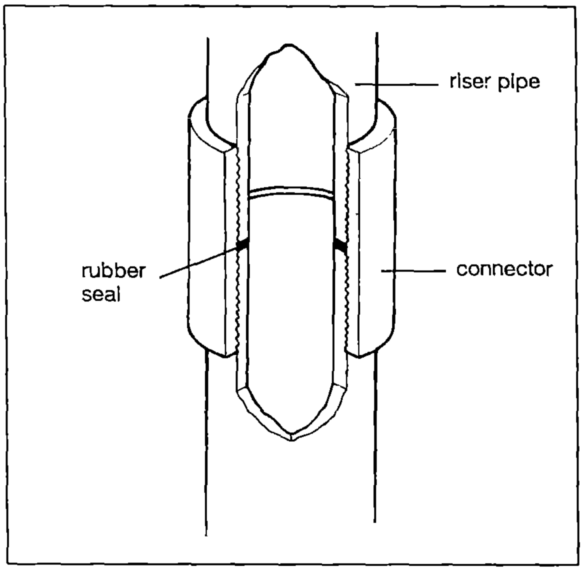
take the pump stand to the workshop;
- weld any cracks shut;
- apply at least 2 layers of coating to the outside;
- apply a suitable bituminous coating to the inside *(since water will constantly be in contact with the inside of the pump stand, be careful to use a bituminous coating that has been officially accepted for use in structures containing drinking water; be especially careful not to use a coating that might contain chemical substances that are injurious to health!)*;

7 One by one remove the remaining risers and pump rods from the borehole or well:

- for SWN pumps:
  - loosen riser clamp and lift riser pipe until connection with next section is approximately 20 cm above riser clamp;
  - fix riser in riser clamp;
  - using two pipe wrenches, disconnect the two riser sections *(since the connectors are fixed to the top of the riser pipe sections, the connection between the* ***upper riser section and the connector*** *must be loosened: apply one pipe wrench to the connector socket itself, and one to the riser pipe just above the connector socket!)* ;
  - lift the section of riser pipe that was just disconnected in such a way that a rod catcher can be put underneath the next pump rod connection;
  - using the rod catcher and a spanner size 17, disconnect the two pump rod sections;
  - carefully take off the disconnected riser/rod sections and remove the rod hanger from the pump rod;
  - check riser pipe for damage and discolouration *(discolouration of the PVC may indicate leakage caused by insufficiently tightened connections: the connection should have been tightened so far that the rubber seal in the connector is compressed by the ends of both riser sections). If this is not the case, leakage may occur, especially if the riser is swinging during pumping* ;



Disconnecting riser sections of SWN pumps



Connection between riser pipe sections

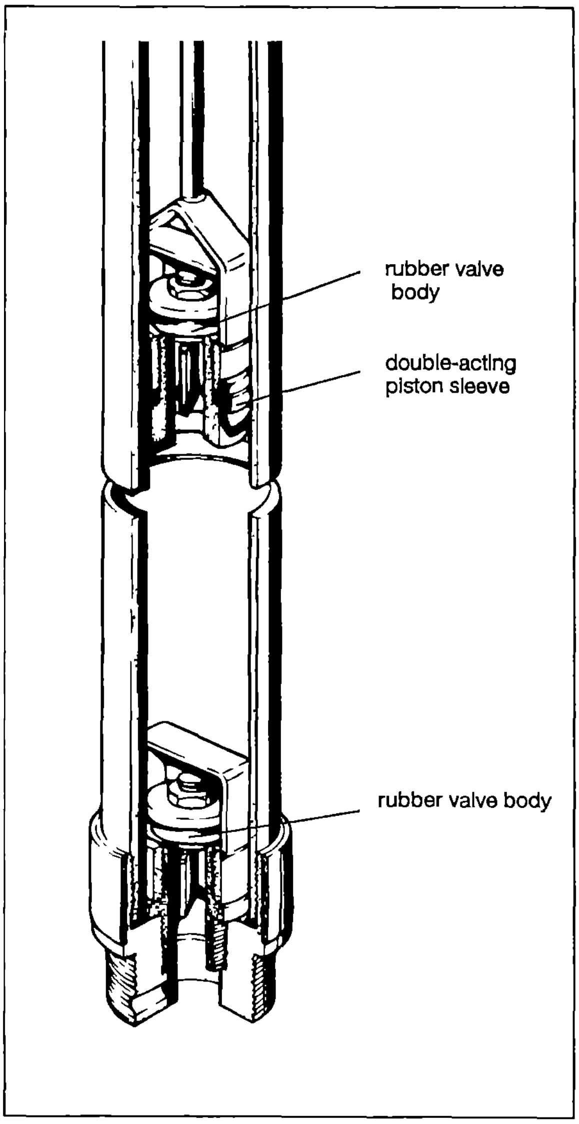
- for non-SWN pumps the sequence is basically the same, but may have to be adapted to the specifics of the pump type used:
  - if GI riser pipe is used, check for wear and corrosion, paying special attention to the sockets *(is the wall thickness locally reduced by corrosion, especially at the threaded ends? Is there discolouration by rust?)*;

- Repeat these activities until only the last riser section and cylinder are left, and carefully disconnect the cylinder from the riser pipe and pump rod;

8 Take the cylinder to the workshop for inspection, repair and overhauling.

(The following activities are based on overhauling SWN cylinders. For other types of handpumps the corresponding activities need to be carried out):

- carefully open the cylinder and take out plunger assembly and foot valve assembly:
  - using two pipe wrenches remove top connector from cylinder body;
  - using one pipe wrench and a screw driver, remove bottom connector/ foot valve assembly *(fit screw driver shaft through holes in bottom connector)*;
- visually check the double-acting piston seal and rubber valve bodies for signs of wear *(in principle these items should last for about 10 years under normal conditions. If visible wear occurs in a considerable shorter period, there is something wrong, most likely with the borehole (sand being pumped)*;
- check cylinder wall for scratches: in case of scratches, reverse the cylinder (if possible);
- replace the worn parts, and reassemble the cylinder.



Cylinder parts to be checked/replaced

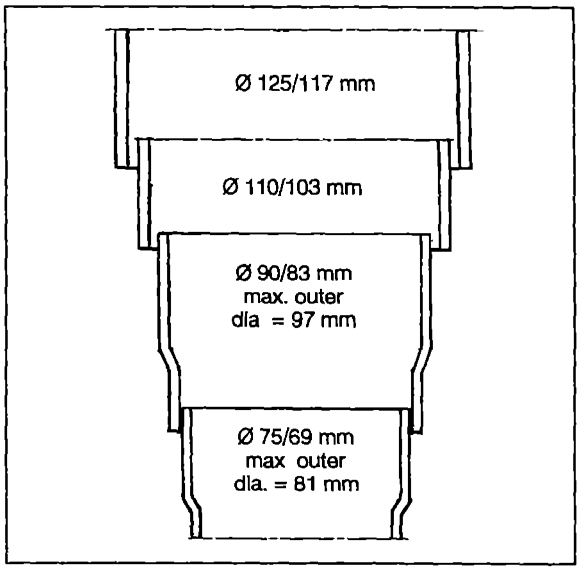
Before re-installing the overhauled handpump, check the well / borehole!

See *Volume 2: Dug Wells* and *Volume 3: Hand Drilled Wells* for a detailed description A summary is given below:

❑ **Borehole**

- clean with brush and bailer;
- with handpump or motor pump check the borehole capacity;
- check the sand content of the water. If sand is found in the water, the possibility exists that the filter has cracked In that case it may be possible to put a smaller-diameter filter inside the existing one·

A PVC casing/filter pipe Ø 90/83 has a maximum width of 97 mm at the socket; a Ø 75/69 casing/filter pipe has a maximum width of 81 mm at the socket. Either size can be fitted inside a Ø 125/117 as well as a Ø 110/103 casing/filter pipe, and either size allows the use of a 2" SWN cylinder (maximum outer diameter = 66 mm). However, in case the borehole is relatively deep, the possible non-verticality of the borehole renders it advisable not to use the Ø 90/83 casing/filter pipe inside an existing Ø 110/103 casing/filter.

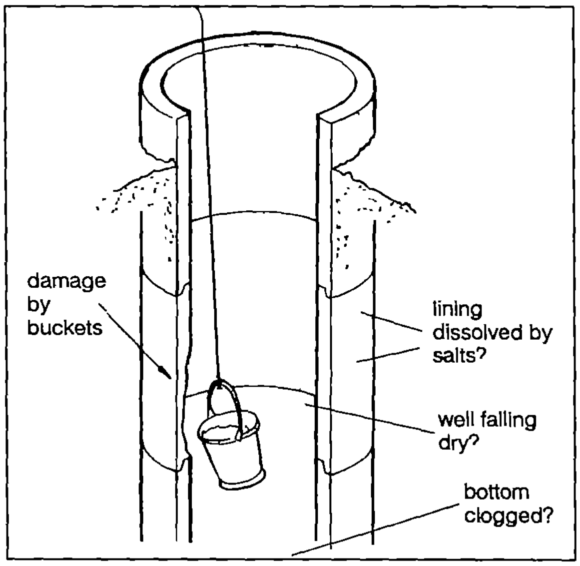


Fitting new casing/filter pipe inside existing one

- ☐ **Dug well**
  - check that the well does not fall dry, even towards the end of the dry season. If it does, it must be deepened first, using concrete filter rings of smaller diameter;
  - check that the upper ring is rock-steady. if it is not, continued use of the well will loosen it further, eventually allowing contaminated water to seep into the well underneath the ring;
  - check that the walls and bottom are not clogged;
  - check for signs that the cement of the lining has been dissolved by salts in the soil or water (whitish bumps grown on the well lining).

    If so, check that the lining is still strong enough to prevent the walls from caving in. Repair lining if necessary;
  - check for damage caused by buckets scraping along the well lining. Repair when necessary.

Keep in mind that in several cases it was found only afterwards that cement had been pilfered during construction of wells, or that contractors had not prepared concrete according to specifications, economizing on cement. In either case this resulted in impaired strength of the well lining, which consequently wears more than necessary with normal use.



Items to be checked, dug well

HANDPUMP COSTS

Assuming that

- ☐ the well or borehole has been well constructed:
  - tubewell:
    - deep enough
    - with a sufficiently long filter pipe section (at least 6 m)
    - tapping an aquifer that is not 'mined' (no continuously falling groundwater table)
    - with a well-designed gravel pack
  - dug well:
    - deep enough
    - with good-quality lining and filter rings
- ☐ the handpump has been well installed:
  - pump foundation horizontal and level
  - cylinder positioned deep enough, but high enough above the well bottom
- ☐ maintenance has been locally arranged

the costs to be expected during the lifetime of the borehole/well are as follows:

Period	Activity	Cost involved
Every month:	- clean up well surroundings - clean gutter - repair fence; keep cattle away	local local local
Each year:	- tighten nuts - putting some oil on main bearing - repair cracks in concrete (platform)	local local $ 15.-
After 10 years:	- remove and check pump in workshop - replace wearing parts (bearings) - new cylinder - replace 50% of pump rods/riser pipe - paint, coating, grease	local $ 30.- $ 150.- $ 300.- $ 20.-
During a 20-year period: 20 x $15.- + $ 500 =		$ 800.-

Including transport, local costs and overhead costs the total maintenance costs for 20 years may easily be in the region of $ 2000, or: $ 100 per year for each handpump, which means

about $ 0.50 - $ 0.75 per year per person.

This is a very reasonable amount, but ....
...someone will have to foot the bill.
If the local people do not have the money, who will pay?

Conclusion:	outside assistance by donors and NGOs will remain indispensable for a considerable time to come, and not only in Africa!

Troubleshooting Chart for SWN pumps

Problem/Symptom	Probable cause	What to do:
a. Pump does not give water; handle is very easy to operate and rests at bottom position	a1. Pump rods disconnected a2. Pump rod broken (very unlikely)	a1. Remove pump head and disassemble below ground level parts. Tighten all rod connections and re-assemble. a2. ditto; replace broken rod.
b. Pump does not give water; operation of handle is normal	b. Water level in well has dropped below pump cylinder	b. Check water level in well. Lower cylinder, if necessary after deepening well. If this is not possible, take out pump and install on other well which is deep enough.
c. Pump does not give water; handle is hard to operate and rests at top position	c1. Riser pipe broken or having major leaks c2. Cylinder disconnected	c. Remove pump head and disassemble below ground level parts. Check all risers and connections for leakage (look for discolourations). Replace any broken pipe, re-assemble and tighten connections well. See that PE protecting sleeve covers all rod connectors.
d. Water takes a long time to reach the spout	d1. Riser pipe leaking d2. Piston valve and/or foot valve in cylinder leaking d3. Cup is leaking d4. Cylinder connection is leaking	d1. see under c. d2. Remove below ground components and open cylinder. Check for wear of piston and foot valves. Replace any worn parts and re-assemble. d3. Replace cup d4. Tighten cylinder connection
e. Pump foundation or platform cracked	e. Abnormal wear or low quality of original concrete construction.	e. Cut out the cracked parts of the pump foundation and replace by fresh concrete of good quality.
f. Pump foundation shaky.	f. Anchor bolts loose.	f. see under e. Keep anchor bolts well aligned during repair of foundation.
g. Poor taste of water	Contaminated water reaching the well: g1. soap from washing clothes g2. infiltration water from latrine	g1. Have washing slab constructed at least 3 m away and downstream from well g2. Relocate latrine, if possible at least 15 m away and downstream from well

Note· For structural problems with wells and boreholes, and how to deal with these, see Volume 2 (Dug Wells) and Volume 3 (Hand Drilled Wells)