

ST 2.1 ROPE PUMP A-MODEL



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This manual is made as an aid in the Production, Installation and Operation & Maintenance of the rope pump A-model. The content is based on input from SHIPO Tanzania, the experiences of Henk Holtslag and Connect international, Jan de Jongh of ARRAKIS and a Practica manual. Some pictures are used from a manual of RWSN-SKAT.

This manual is part of the main manual, named “ST 2 Pumps”. Other manuals in this range are:

- ST 2.2 Rope pump Windlass model;
- ST 2.3 Training of rope pump production companies.

Each manual can be used separately from the other manuals.

To avoid errors and inventing wheels in the production and installation, it is necessary to combine this manual with a practical training which can be supplied by Connect International. Please do not hesitate to contact us.

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1 Introduction

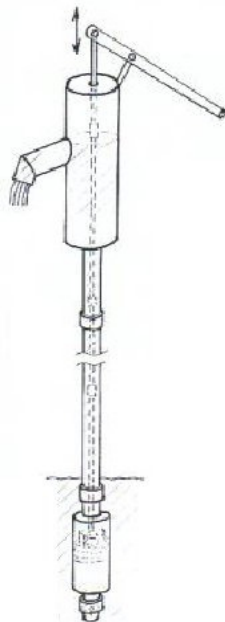
The height of the A-model depends on the use. For boreholes the length of the legs is 1 meter, for hand dug wells the height of the legs can be 0.6 meter.

Hand pumps can be divided in:

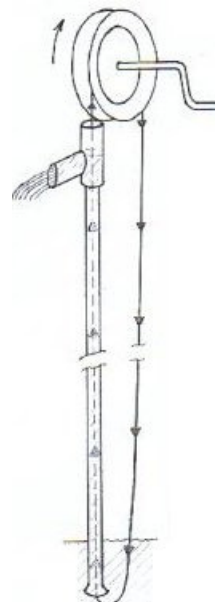
- Suction pumps;
- Lifting pumps.

Suction pumps have a piston situated on ground level. Water is sucked upwards by the piston because of the relative under-pressure below the piston. Theoretically the suction head of a suction pump is only 10 meters, unfortunately in practice this is 6 to 7 meters. A good example of a suction pump is the 'treadle pump' also known as 'Money Maker'. These pump types are relatively inexpensive and can be produced and repaired locally.

Lift pumps have a cylinder and one piston below the water level. Water is forced upward by the piston. In general, pumps of this type are more expensive compared to suction pumps as it requires long pump rods and rising mains. Examples are the Nira-, Afridev-, Indian Mark- and Volanta pump. Another example of a lift pump is the so called 'rope pump' which has a rotating movement. With new design inputs and modern materials, the rope pumps are nowadays very efficient, reliable and affordable and pump up water from wells as deep as 35 – 60 meter. This manual tells about the rope pump (A-model).



An Afridev pump



A rope pump

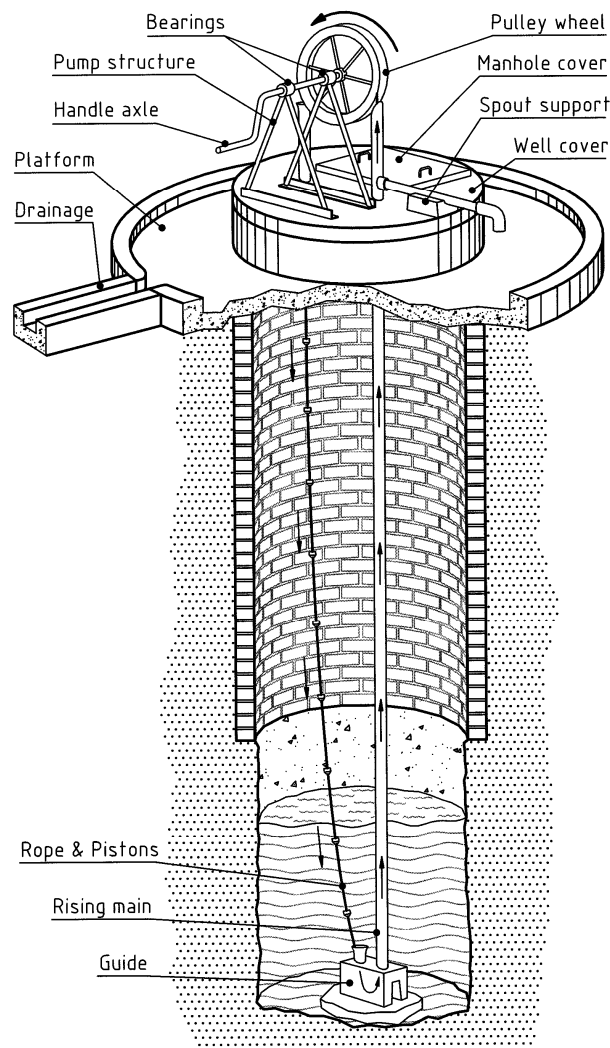


2 The rope pump

2.1 How it works

The rope pump consists of a wheel and an endless rope with pistons made out of care tire. The pistons are attached to the rope at intervals of 1 meter.

The pistons fit with a clearance of 1 millimetre in the PVC-pipe (called raising pipe or raising main). The rope and pistons go all the way down to the bottom of the well where they fetch water and bring it up through the raising pipe. The rope is led by a guide box into the raising pipe. The rope and pistons come in motion by turning the wheel. The wheel and handle are mounted on a structure on top of the well. Rope pumps can be used on hand dug wells as well as boreholes with a diameter as small as a 2 inch.





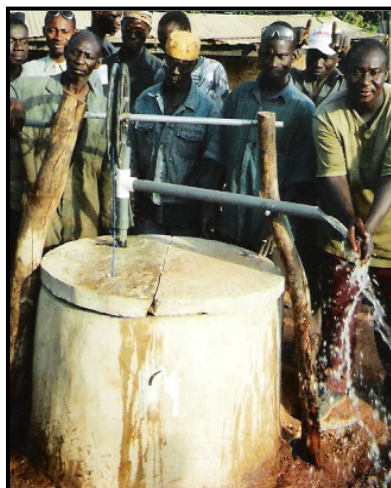
2.2 Features of the rope pump

Of the hand rope pump there are 2 basic models:

- A-model: the pump's structure is in the shape of the letter 'A'. There is a short base model and a long base model. Short based models are normally used for hand dug wells. This manual gives you all the details how to produce these kind of models.



- Windlass-model: this model is mounted on poles next to the borehole or hand dug well. The windlass-model is normally used as a family pump and not as a community pump. The A-model is more suitable as a community pump because due to his steel construction it is much stronger. The windlass-model is much cheaper than the A-model. This model is described in manual ST 2.2 Rope pump Windlass-model.





For higher yields, there are models powered by pedals, electric motors, gasoline engines, animal traction and wind mills. Please contact Connect International if more information is required about these models.

Depending on the depth, the rope pump has a maximum discharge of 40 liter per minute.

Water table (meters)	Discharge (liters per minute) *	Remarks
10	40	
35	10	
60	7	A double handle to lift the water

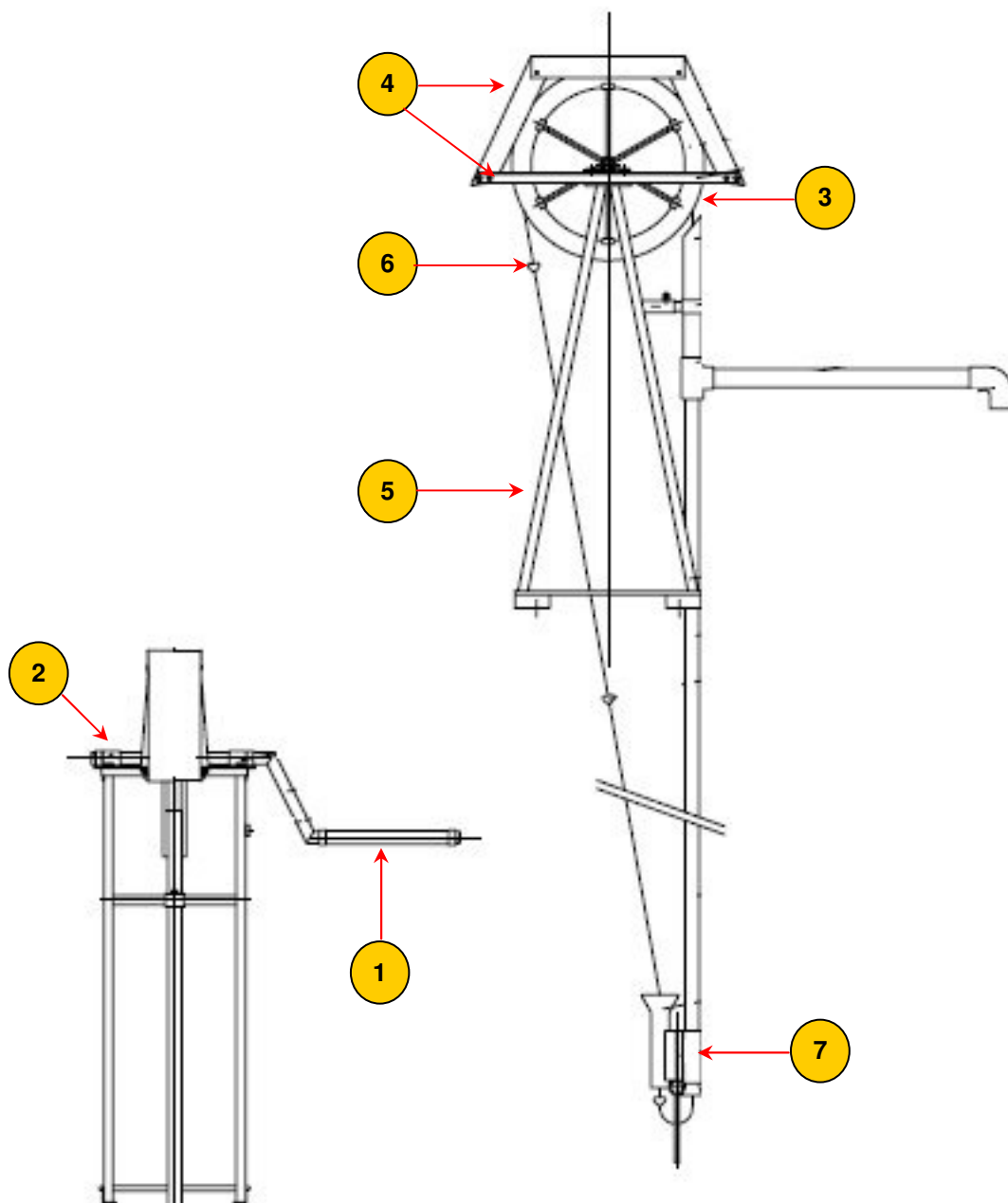
* based on a power of 50 Watt; the power that women and children can deliver for longer periods.

The lower the water table, the longer the raising tube will be and therefore also the weight of water that has to be carried up to ground level. There the tube diameter depends on the depth of the water level. The deeper the water table is, the smaller the tube diameter (see chapter 3.6).



3 Construction

This chapter explains how to construct a rope pump. It is divided in several subchapters. Every subchapter gives a general description of that specific part of the rope pump and how to construct it. The parts are explained in order and as numbered in the below standing picture (1 = axle and handle, 2 = bushings, 3 = wheel, 4 = cover and cover supports, 5 = pump structure, 6 = rope and pistons, 7 = pipes and guide box).



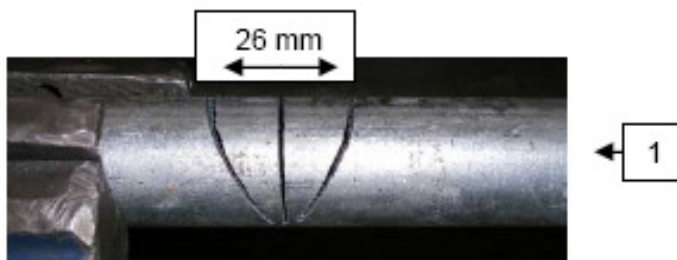


3.1 Axle and handle

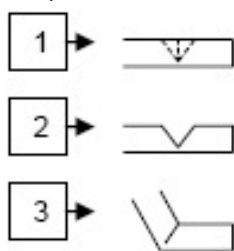
The axle and handle are together with the bushings, the most critical part of the pump. The axle is liable to irregular forces created by the users. Therefore a wall thickness of 3 to 3.5 mm is essential. Galvanized pipes with a wall thickness of 2.5 mm or less will break within months of operation.

Nr.	Item	Material	Dimensions	Size	Quantity
1	Handle	Galvanized pipe	880 mm	3/4"	1
2	Grip	PVC pipe	230 mm	1"	1
3	Spacer ring	Galvanized pipe	7 mm	1"	4

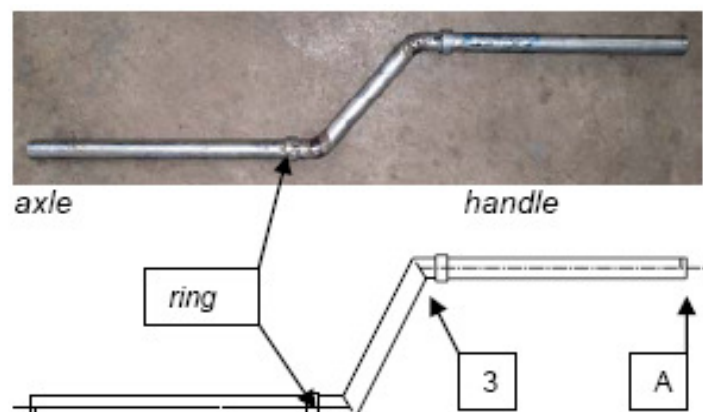
For bending the axle, cut V-shaped grooves with a hack saw as shown in the picture. Make sure the axle and handle are parallel to each other and weld the. Weld rings with 3 spot welds on one side. For more production details see chapter 7.1.



Step



handle with ring and grip lock



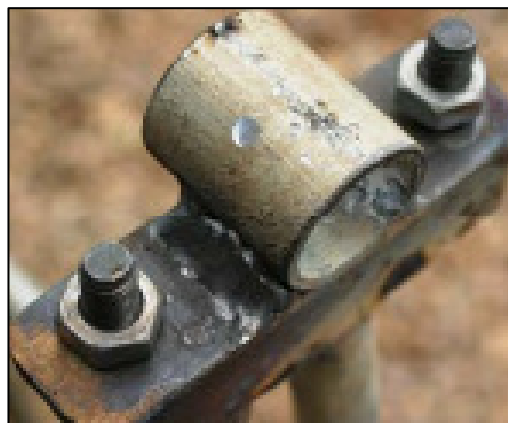


3.2 Bushings

The bushings consist of galvanized (GI) pipe and iron strip. The galvanized pipe serves as the bushing and supports the axle. It is very important that the bushings on both sides of the structure are fixed exactly in-line. If not, the edges of the bushings will cut into the axle, finally resulting in a broken axle. Therefore the use of a welding jig is necessary. Drill lubrication holes (6 mm) in the bushings.



Bushings exactly in line



Bushing with a lubrication hole

To prevent wear on the axle and bushing, the sharp edges, seam and burr have to be filed out until the inside and edge of the bushing show a smooth surface.

The bushing has to fit exactly around the axle (max. 0.5 mm space) to get a proper working oil film. Too much space makes the oil film tend to break and both, the bushing and the axle, will wear out faster. If the space between the axle and bushing is too much, use galvanized pipe for the bushing with a thicker wall thicknesses. If this is not available reduce the diameter of the bushing by removing a piece and well it back in the right diameter. Take 3 millimeters of material out for 1 millimeter reduction in diameter.

Always use a bushing jig when welding the galvanized pipe to the iron strip. Add 6 mm round-bar along the side of the pipe to create more welding space. Make short welds at the time to prevent deforming. Use filler of 3 mm welding rod. Drill holes in the bushing strip of 11 mm to allow the bolts to pass (see picture above). File the sharp edges.

Nr	Item	Material	Dimensions	Size	Quantity	Remarks
1	Bushing ring	GI pipe	50 mm	1"	2	Wall thickness of 3 mm
2	Bushing strip	Strip	100 x 25 mm		2	Thickness of 3 mm

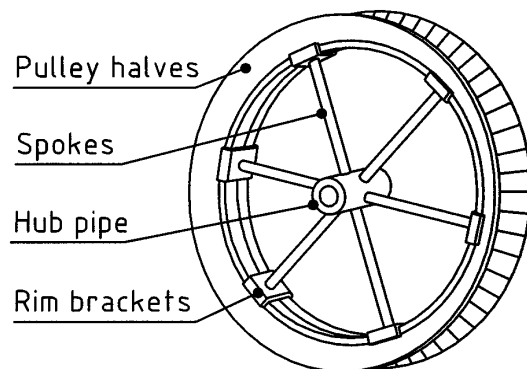
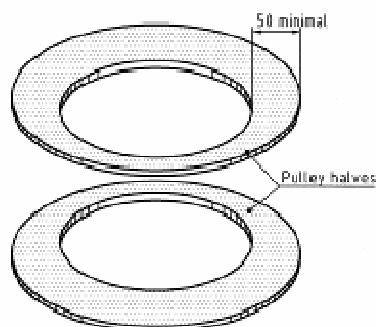
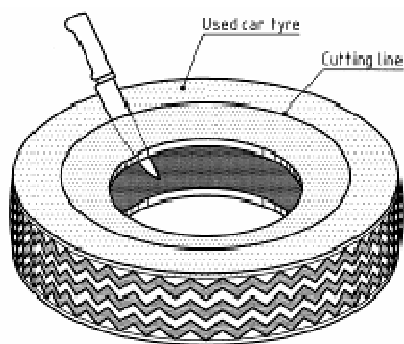


3.3 Wheel

The most important part of the wheel is the V-shape, created by the two pulley halves of a 14" car tire . They are kept together by the rim brackets. The weight of the water column forces the rope into the V-shape, creating more resistance between the wheel and the rope. This prevents the rope from slipping (it's therefore that U-shaped concrete wheels don't work).

Nr	Item	Material	Dimensions	Size	Quantity	Remarks
1	Hub pipe	GI pipe	100 mm	1"	1	
2	Spokes	Round bar	156 mm +/- 0,5	Ø 10 mm	6	
3	Rim brackets	Strip	65 mm	25 x 3 mm	6	Size depends on type of tire
4	Spar support	Round bar	100 mm	Ø 10 mm	3	Optional
5	Nut	GI		M 10	2	
6	Bolt	GI	25 mm	M 10	2	
7	Pulley halves	Car tire	45 mm	14"	2	

Drill holes in the hub pipe and weld the nuts onto these holes. To prevent deforming, keep the bolt in the nut during welding. Protect the thread of the bolt with grease. Use rust-resistant bolts and nuts. Turn the bolt so it reaches the axle and therefore can hold the right position of the wheel. For more production details see chapter 7.2.



Nuts are welded on the hub pipe



3.4 Cover and cover supports

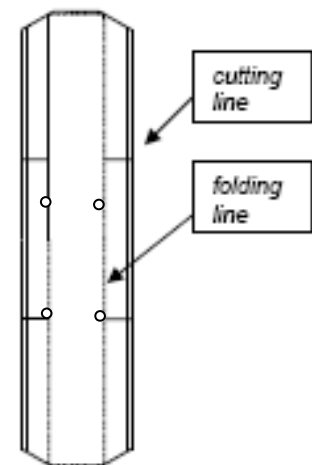
The cover support is welded onto the bushing support on the structure. Bend the cover support by cutting a piece out of it. Weld it in the right position and smoothen the welds with a grinder. For more production details see chapter 7.4.



Cover supports



A galvanized cover



How to make the cover:

- 1) Cut the plate in the right shape and file the sharp edges;
- 2) Drill 4 holes of 6 mm at end of cutting lines (to avoid cracking with the bending of the plate). See drawing;
- 3) Drill holes for rivets on one side;
- 4) Fold the cover in shape at the dotted lines;
- 5) Mount the cover on the cover support with rivets;
- 6) Hold cover straight and use the holes on one side to drill the additional holes for the rivets;
- 7) Mount the rivets.



To be able to 'track' the pump and monitor its quality, it is advised to add a unique serial number and workshop initials to each pump. The workshop should keep a log book including:

- Serial number;
- Production, Selling and Installation date;
- Name of the buyer and place of installation;
- Model.

Nr	Item	Material	Dimensions	Size	Quantity	Remarks
1	Cover	GI sheet	1000 x 200 mm	1"	1	0.7 - 1 mm
2	Pop rivets	Steel	25 mm	Ø 4 mm	18	Or bolts M 6 x 20
3	Cover support	Angle iron	500 mm	25 x 25 x 3 mm	2	
4	Registration	Steel strip	400 x 100 mm		2	

For more production details see chapter 7.3.



3.5 Pump structure

The structure consists of galvanized pipes, angle iron and reinforcement bar. These materials have a thin wall thickness and are therefore sensitive to deformation during welding. It is important that 'top' (for assembly of the bushings) and 'bottom' (for construction on slab or well cover) of the structure remain straight.

Drill holes (11 mm) in bushing support. Cut legs and other parts. Place parts of the blocking system on front right leg. Hammer ends of horizontal pipes oval (to facilitate welding). Weld the whole structure by using a jig.

Remove the structure from the jig and weld to the bottom legs foundation bar to create more gripe when the structure is placed in the concrete cover or apron. Mount bushings on bushing supports and mount these on the pump structure with a 3/4" pipe to make sure the bushings are aligned well. Weld bushing supports to pump structure. Weld the outlet pipe support system.

To avoid the handle from turning back rapidly after pumping is stopped and the handle is released, a blocking system is included. This is a hook and hinge connected to a leg. For more production details see chapter 7.5.



Nr	Item	Material	Dimensions	Size	Quantity	Remarks
1	Leg	GI pipe	1000	1/2"	4	Short model 600 mm
2a	Blocking system	GI pipe	170	1/2 "		Adjust
2b	Blocking system	GI pipe	50	3/4"	1	
2c	Blocking system	GI pipe	7	3/4"	2	
3	Horizontal pipes	GI pipe	250	3/4"	4	
4	Foundation bar	Bar	350	Ø 8 mm	2	
5	Foundation bar	Bar	450	Ø 8 mm	2	Short model 300 mm
6	Outlet support	GI pipe	100	1/2"	1	Short model 300 mm
7	Outlet support	Strip	260	25x 3 mm	1	
8	Bushing support	Angle iron	105	25x25x 3 mm	2	
9	Bolts and nuts	GI		M10x20	4	



3.6 Rope and pistons

Rope

Rope of polypropylene (PP) gives the best results. Nylon can also be used. It is stronger than PP rope but it tends to slip on the wheel. To avoid slipping, the rope can be roughened with a stone or hacksaw. Also the wheel V-groove can be roughened with a hack saw, or a strip of inner car tube can be mounted.

The rope length should be twice the depth of the borehole/ well + 2 meters extra + 5% rope extra (for the knots). The rope thickness is for wells up to 35 m preferably 6 mm although 5 mm is allowed. For wells deeper than 35 meter it is recommended to use a rope of 8 mm.



A rubber piston on a rope, between two knots

Pistons

Pistons can be made of different materials, most common are rubber or polyethylene (PE). Rubber pistons can be made out of the side part of a used car tire. Rubber pistons have the advantage of being cheaper and scraping less in case of sandy water. PE pistons are more attractive looking and may be easier accepted by government, NGO's and donors.



Prefabricated PE pistons



Use a sharp mould to make the pistons

One piston is placed every 1 meter of the rope. The pistons are fixed to the rope with two knots. The pistons should be 0.5 - 1 millimeter smaller in diameter than the inner diameter of the pump pipe.



The diameter of the piston depends on the diameter of the pump pipe. The diameter of the pump pipe depends on the total elevation (meaning distance between water level and outlet). Elevation should be measured for the worst situation, normally at the end of the dry season after some time of continuous pumping.

The deeper the water level, the smaller the pump pipe and pistons!

A PVC pipe with an inner diameter of 30 millimeters contains approximately 700 millimeters of water per meter. This amount of water is equal to 0.7 kilogram (kg). If this pipe is used in a well with a water level on 10 meters, the total weight of the water column will be: $10 \times 0.7 \text{ kg} = 7 \text{ kg}$. This weight can be lifted easily by the user.

However, if the water level would be 30 meter, the total weight of the column would be: $30 \times 0.7 \text{ kg} = 21 \text{ kg}$. This is too heavy for the average user of the pump. Therefore the weight of the water column has to be reduced by using as smaller diameter pump pipe. The below standing table explains what diameter to use for what elevation.

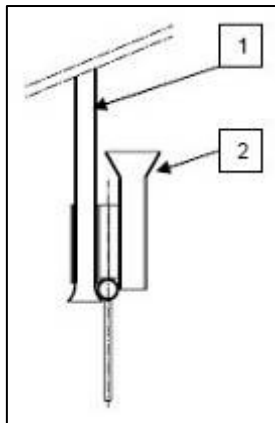
Elevation (meters)	Pump pipe diameter inside	
0 - 4	40 mm	1 ½ inch
4 – 11	30 mm	1 inch
11 – 20	23 mm	¾" inch
20 – 35	18 mm	½" inch
35 - 60	18 mm (double handle)	½" inch

The PVC inner and outer diameters of the pump pipe are different from country to country and even from factory to factory. The diameters given in this table are indicative numbers. The pump pipes should have, on average, a wall thickness of 1.5 – 2.5 mm.



3.7 Guide box

The guide box will guide the rope and pistons into the pump pipe at the bottom of the borehole or well. The rope and pistons move freely (no pipe) down into the borehole or borehole and are guided by a flared 'inlet' pipe (2) into the pump pipe (1). A glass bottle will guide the rope smoothly into the upgoing pump pipe (see also the picture on page 4 of this manual). Making the flare is explained in manual ST 1.4 Finalization of the rope pump (chapter 2.7).



Raising pipe and flare



A small glass bottle situated at the guide box



Concrete guide boxes

Normally in a borehole, a small guide box is made because it has to fit in the casing. In open wells the guide box has a concrete foot (see right picture). The extra weight will make sure the guide box is hanging stable and is not making too much movement in the water (that could cause turbid water). Several different models can be made of each type of guide box.



Corrosion on a guide box

Corrosion of the guide box can infect the quality of the water. The guide box should be painted with anti oxide paint or the guide box should be executed with galvanized materials. For more production details see chapter 7.6.



A painted guide box (even than rust may occur. Check regularly)



3.8 Painting

To avoid corrosion, the structure has to be painted. For good painting it is important to follow the next guideline:

- 1) It is essential to paint all the parts that are not galvanized (also the weldings). Galvanized steel will not rust;
- 2) Remove all welding slack and visible grease with solvent and remove rust with a steel brush;
- 3) Apply anti-rust primer paint;
- 4) Allow painted parts to dry in the shade. Not in the sun. When dried in the sun, blisters occur;
- 5) After the anti-rust primer paint is completely dry, paint the structure with gloss paint. Make sure hands are free of grease during handling of the structure. Do not dilute the paint unless really necessary (only when the paint is too thick and can only be applied with great resistance). If you have to dilute the paint use paint diluter not gasoline;
- 6) Always paint the parts before assembling, not after wards;
- 7) Close the paint cans carefully after painting. Hold the can up side down for some time to see if it is closed properly. In that way, the paint will lock the seam of the lid properly.



Rust on the cover supports (angle iron) indicates that the welding slack is not removed properly. Rust between the bushing and bushing support indicates that these are painted after assembling, not before.



Painting with anti-rust paint



3.9 Jigs

When starting rope pump production it is strongly recommended to produce welding jigs. Although dimensions in the drawings are standardized, in practice, critical parts like the structure or the bushings mostly end up having different dimensions if welding jigs are not used. This is partly due to expanding and shrinking of the metal during the welding process. These small variations however, can have a large influence on the functioning and life time of the pump.

But there are more reasons to standardize the rope pump production. By using welding jigs, all pumps and parts will be identical. The advantage of this shows itself in future. When, for example, the bushing breaks down, it can easily be replaced by a new one from the workshop, without replacing the whole pump. Because of the standardization the new bushing will easily fit the old pump. For series or mass production, using the welding jigs, all parts can be constructed separately.

Jigs should be used for the following parts:



A-model structure jig



Piston jig



Bushing jig



Handle jig



Wheel jig



4 Quality control

Although the rope pump technology is relatively simple, there are still many details in production and installation that can go wrong. Experiences in several countries indicate that “simple is not easy”. A manual is often not enough to ensure the quality. Quality is crucial, especially when the rope pump has to build up an image for government, NGOs and donors.

For quality control, monitoring is essential to detect problems in time. After the first 15 pumps, it is recommended to evaluate the pumps and use the results in follow-up training by an experienced trainer (trainings can be organized by Connect International).

Important for producing a good quality of rope pump, it is necessary to use the right tools that are in good condition. Correct measurements are the key for quality. Use measuring instruments only for measuring! Tri-squares for example, are designed to measure a squared (90°) angle, but are often misused to remove welding slack. See photo: these tri-squares were misused to remove welding slack. None of these tri-squares show a 90° angle!



Tri-angles?

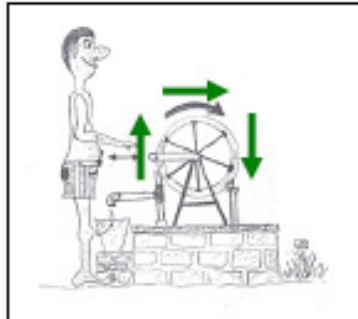
Make yourself a checklist by using this manual and make sure you did everything correct and you didn't forget things. Put this checklist combined with the registration number of the pump, in your administration.



5 Operation and maintenance



pump direction



don't hang on the handle



pump lock closed if not in use

pump lock open during operation



lubricate the bushings



check rope play



making a loop



the loop / seam end of the loop



Potential repairs of a rope pump are:

- Replacement of the rope:

Pistons usually last about twice as long as the rope. When the rope shows a lot of damage, the rope should be changed preferably before it breaks. Tie the new rope (with the pistons) to the old rope (be sure the pistons are running in the right direction) and pass it through the raising pipe. It is not necessary to take out the whole raising pipe by doing so.

- Replacement of pistons:

The pistons could be changed, when the user has noted a reduction of the output. Before changing the pistons, check the clearance in a piece of raising pipe to make sure the reduced output is due to worn out pistons.



A worn out piston

- Painting:

To avoid corrosion, it is essential to paint parts again that start corroding.

- The bushings:

If bushings are worn out, dismantle and replace them. If the seizures are right and the bushings are properly oiled, they last for 10 years or more!

- PVC tubing:

If the well contains fine sand, the sand will wear out PVC parts as well. In case wear is excessive, replace PVC parts that are worn out.



6 Machines and tools for rope pump production

Below is a list with machines, tools and consumables that are at least necessary to start rope pump production. Spares like extra hack saw blades or drilling bits are not included.

Machines:

- Electric welding machine, 230 Volt, 150 Ampere;
- Hand drilling machine;
- Angle grinder;



Tools:

- Hand pop riveter for 3 millimetres rivets;
- 2 Spanners size 17 (for 10 mm bolts);
- Hack saw;
- Sheet cutter for sheet up to 1 mm;
- Flat file and round file;
- Square;
- Pliers;
- Set drill bits (3 mm to 12 mm);
- Steel brush;
- Hammers (normal, heavy and welding hammer);
- Work bench with vice;
- Lighter and wood or torch material;
- Scratch pens (for drawing on steel) and permanent markers;
- Ear and eye protection (when using the angle grinder);
- Measuring equipment like angles, tape and calliper.



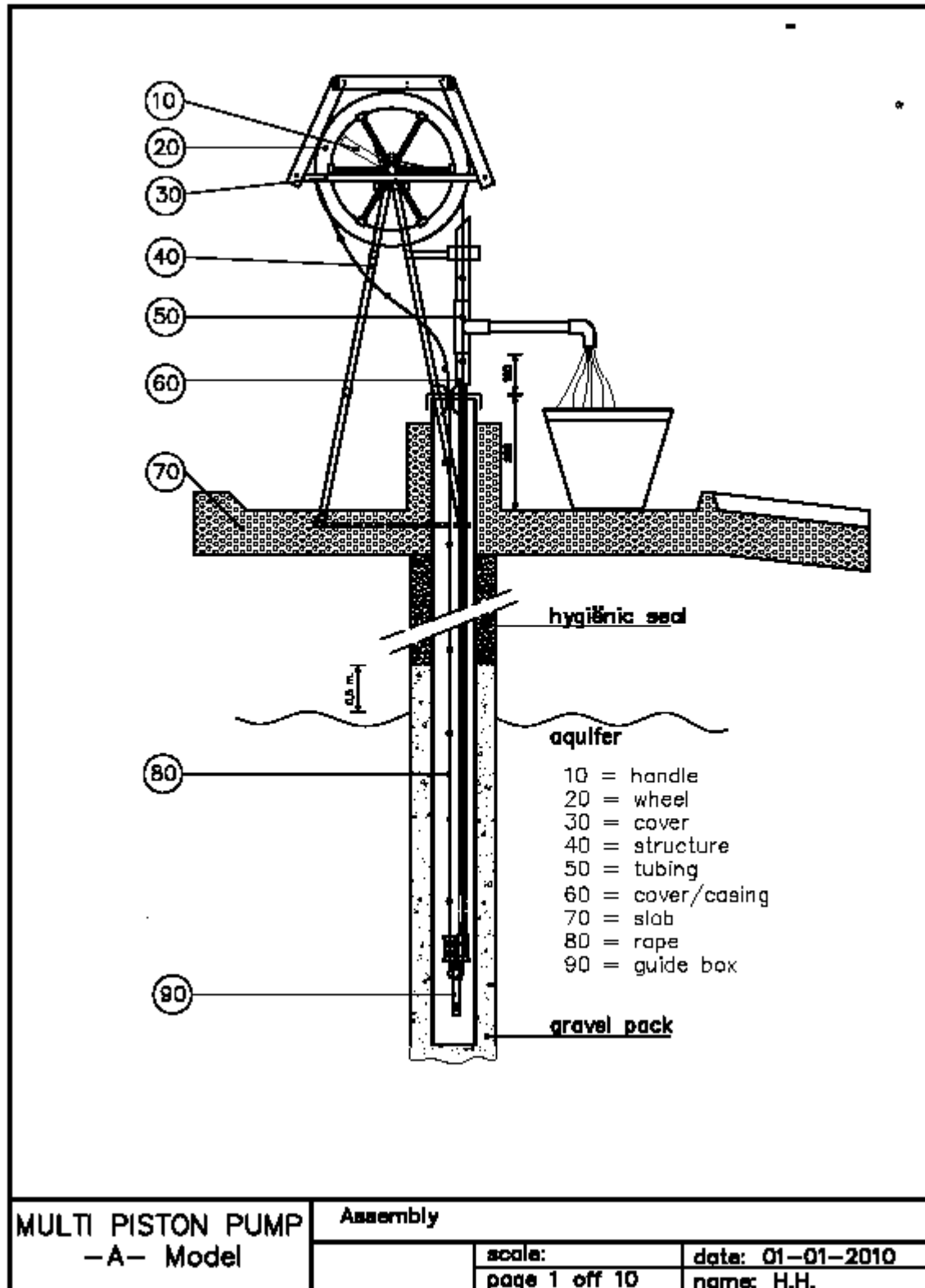
Consumables:

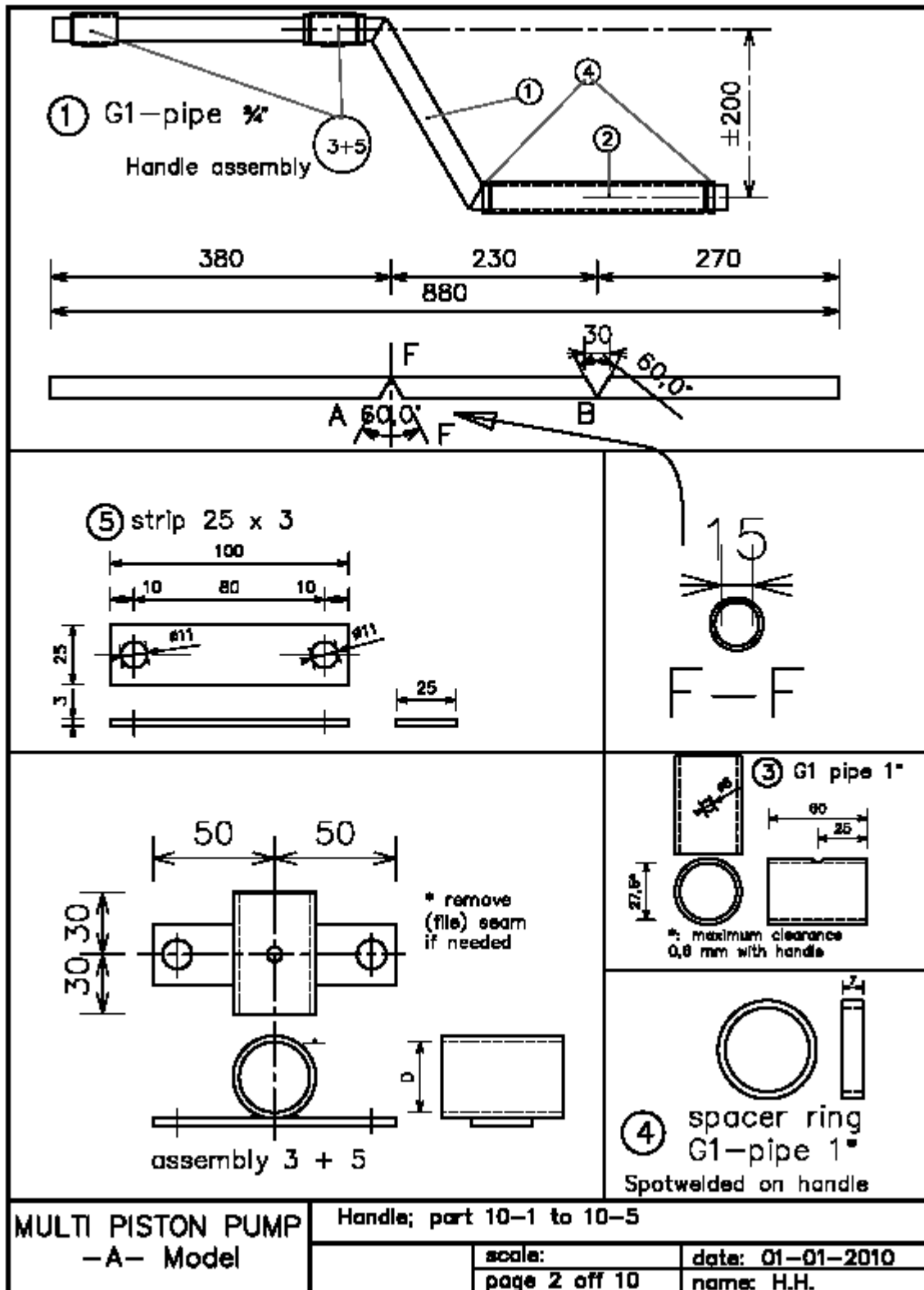
- Electrodes 2.5 mm;
- Pop rivets;
- Anti corrosive primer;
- Gloss paint;
- Oil 10 W 40 (for drilling and oiling the bushings).

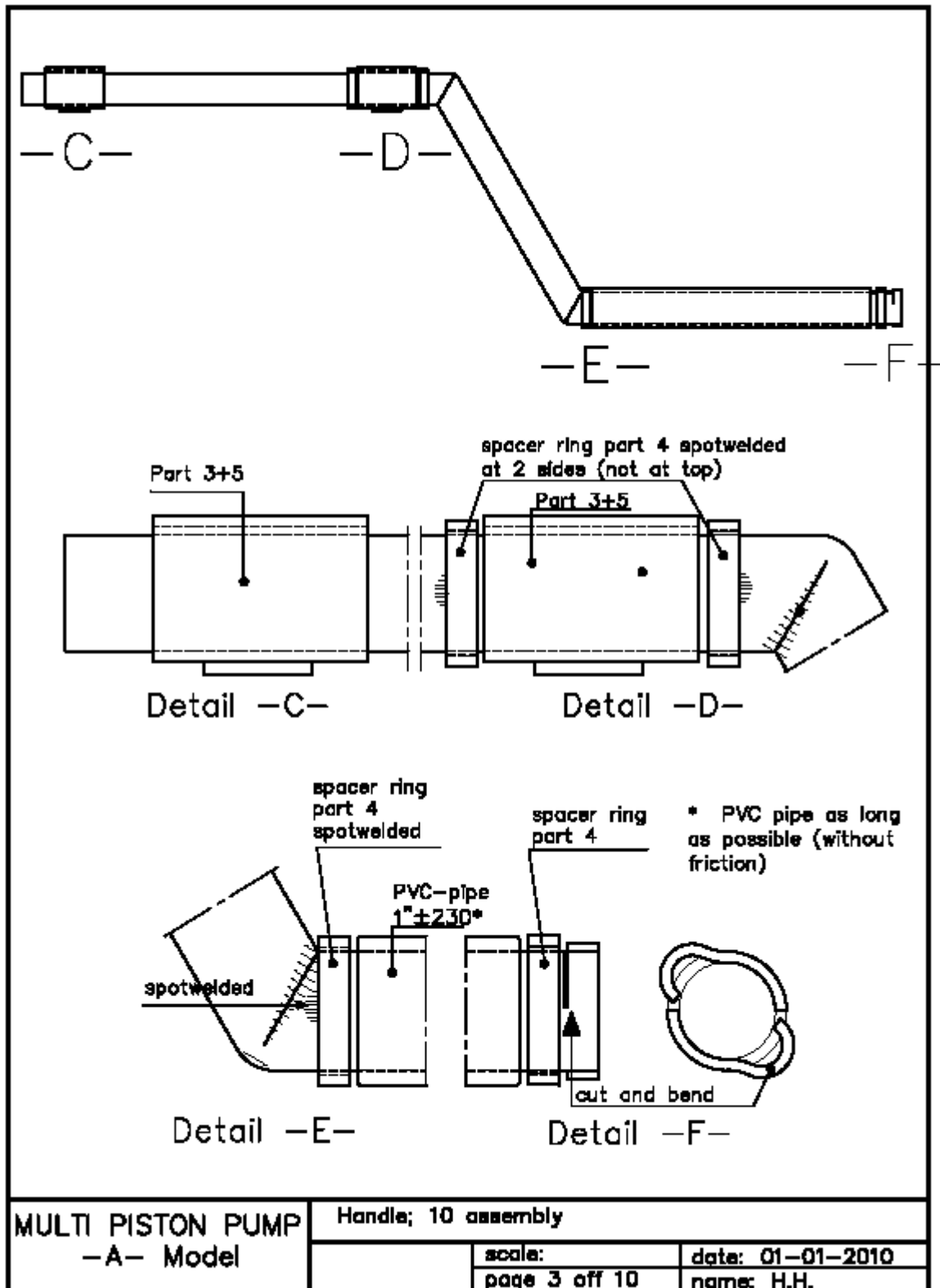


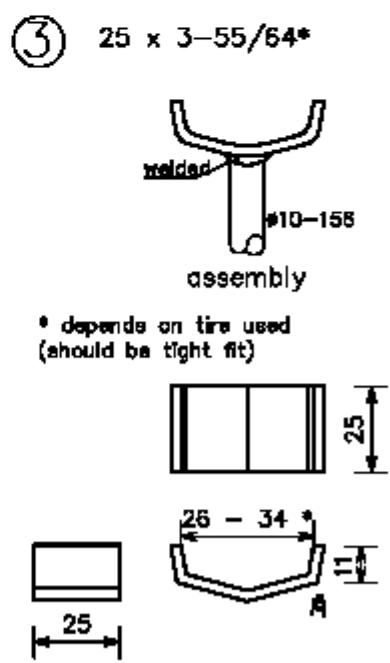
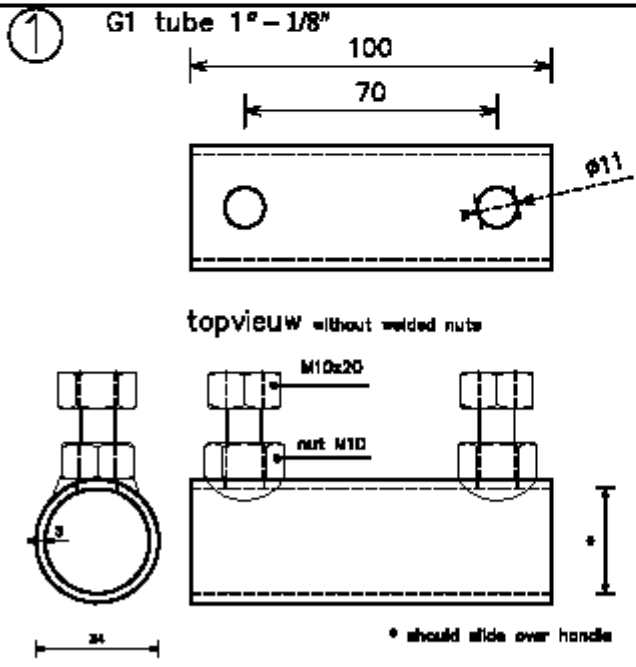
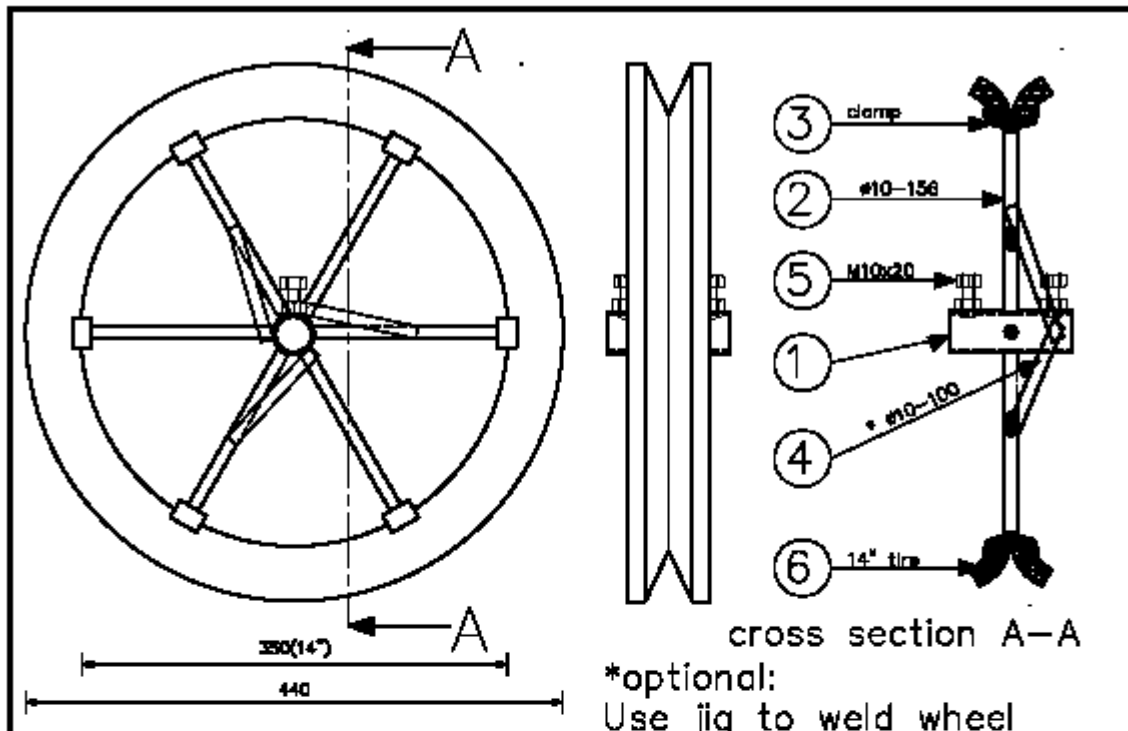


Drawings 1- 01- 2010









MULTI PISTON PUMP -A- Model	Wheel: 20 assembly and parts	
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