Construction Manual for the Integrated Pump

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Construction Process

Design Description
The style of pump that we have designed is a positive displacement pump. There are several standard components that are associated with any positive displacement pump. These include the riser pipe, foot valve, piston, and piston rod.

Riser pipe –
Purpose - shaft through which water is raised
Materials - 2” PVC schedule 40 pipe

Foot valve –
Purpose - check valve in the bottom of the pump that allows the water to enter the pipe but not exit
Materials - Flattened PVC pipe, rubber flap, ¼” bolt, washer, lock washer, and 2 nuts

Piston –
Purpose - moving check valve which allows water to flow through it in the upward direction but not in the downward direction
Materials - Flattened PVC pipe, rubber flap, leather cup, ¼” bolt and washers

Piston rod –
Purpose - drive shaft which raises and lowers the piston
Materials - ½” steel rod, ½” and ¼” double nuts

Outlet –
Purpose - outlet pipe for water to flow out that can be no higher than the top of the riser pipe
Materials - PVC Tee, 2” PVC pipe

Along with these components, we have chosen to add a component that will allow us to pump the water above the top of the riser pipe. This extra component we have chosen to call the seal

Seal –
Purpose - seals around the piston rod so that only minimal amounts of water will be lost
Materials – Flattened PVC pipe, rubber flap

With these components defined, we will now walk you through the construction process of our pump.
Preparation – length calculations

- Measure the total depth of your well ($H_t$), from the bottom of the well to the top of your well casing.
- Measure the average depth of your water.
- It is best to keep the bottom of the pump approximately 12” off the bottom of the well if possible. If your water depth is not over 24” then you will probably need to put it between 6” - 12” from the bottom. If the pump is too close to the bottom it could suck in dirt and other debris and get clogged.
- Take the total depth of your well and subtract the height of the pipe off the bottom that you desire. Subtract another 6” for the check valve at the bottom. This value is how long the 2” PVC chamber needs to be for the assembly.
- Take the value calculated and subtract 6”. This is the overall length for the ½” steel piston rod.

$$\text{_________ (}H_t\text{) - 12” = ________ } L_{PVC}$$
$$\text{_________ (}L_{PVC}\text{) - 6” = ________ } L_{Rod}$$

Pump Body

- Connect 2” PVC pipe together to create the length $L_{PVC}$ calculated.
- Connect ½” steel rods with ½” double nuts to obtain length $L_{Rod}$ while only cutting one section of the rod.
- Use 2 ½” hole saw to cut 3 discs from a flattened piece of 4” PVC pipe. Cut another disc with a 2” hole saw and another disc with the 1.75” hole saw. Keep the circular holes to use for the foot-valve and seal.

Alternatively:

*Draw circles of the appropriate diameter on the flat sheet of PVC with a compass.*
*Use a coping saw or hacksaw to cut out the circles and a metal file to round the edges.*
*If the hacksaw method is used, the discs will not have a ¼” hole in the center, so extra care must be taken to center the hole that will be drilled.*

Figure 1 - Exploded WAP rower pump
• Check the size of the discs with a 2” section of PVC pipe. The discs should come out approximately to the outer diameter of the pipe without extending beyond it. A metal file can be used to grind down the edges until they fit. File evenly around the edge so that the center holes are still centered.

Foot Valve Construction
• Lay out 6 – 1/2” holes in this disc evenly spaced (every 60 degrees) around the circle centered at an approximate radius of 9/16” on flat piece of PVC.
• Drill the 6 – 1/2” holes
• Use a 2 1/2” hole saw to cut the outside diameter of the disc
• Trim the disc to an outside diameter of 2 ¼”
• Cut a circular piece of rubber to fit the inside diameter of the 2” PVC pipe (approximately 1 7/8”).
• Punch a ¼” center hole in this rubber flap.

Foot-Valve Assembly
• Slide PVC disc and rubber flap onto the ¼” bolt
• Slide washer on top of the rubber flap and lightly secure with a ¼” nut (do not deform the rubber).
• Lock this nut in position with a lock washer and second nut

Piston
• Connect ½” steel rod sections together with double nuts to provide the necessary piston length determined in step 3.
• If cutting the rod was necessary, thread the cut end with a ½” die to allow for easy connection to the piston.
• Weld a ¼” double nut in line with a ½” double nut to connect the piston rod to the piston.

Piston Check Valve Construction
• Cut 2 discs to a diameter of 1.625” from the flattened PVC (use 2” hole saw to cut holes if available).
• Drill a ¼” hole in the center of these discs if not already present.
• Punch a ¼” hole in the center of the 2” leather cups.
• Assemble the two PVC discs and leather cup with one disc inside of the leather cup and one disc on the outer face of the cup.
• Put ¼” bolt through the center of all three components.

• While the discs and cup are in place, drill the 6 – 3/8” holes in a circular fashion as done for the foot-valve. Center the holes at a radius of 7/16”

• Cut Rubber flap to fit the outer diameter of the PVC disc inside of the leather cup (approximately 1.625”).

• Punch a ¼” hole in the center of the rubber flap.

• Assemble piston with a ¼” bolt at least 2.5” long (fully threaded). Put a ¼” washer on first and then the drilled discs and leather cup from above with the edges of the leather cup facing upwards. Slide on the rubber valve and secure with a washer and nut. (See Figure 2)

![Figure 2 - Exploded piston check valve](image)

• Attach the piston assembly to the piston rod with the combined double nut (See Figure 3). Make sure to attach the piston to the end of the piston rod that has the shortened rod.

![Figure 3 - Piston attachment to driving rod](image)
Seal Construction

- Cut three discs from flattened PVC pipe to a diameter of 2.25” with a hole saw
- Drill ¾” holes in the center of each disc
- Cut two rubber flaps to a diameter of 2.625”
- Punch a ¼” hole in the center of rubber flaps
- Cut two 6” pieces of 2” PVC pipe
- Flare one of these pieces 2” on one end

Seal Assembly (Figure 4)

- Slide one PVC disc into the flared portion of the pipe
- Center one rubber flap on the next PVC disc.
- Slide the rubber flap into the flared portion making the rubber wrap around the edges of the disc to seal it against the edges
- Slide last rubber flap and PVC disc into the flared portion in the same way
- Slide the straight portion of PVC pipe into the flare to secure everything
Final Assembly

- Glue Foot valve assembly onto the end of a short piece of PVC pipe (approximately 6”)
- Glue this foot valve into the base of the riser pipe
- Slide the fully assembled piston rod into the PVC riser pipe at the end with the tee, piston first.
- Slide the seal assembly around the top of the piston shaft and press into the top of the PVC tee
- Attach PVC pipe to the side of the tee that will outlet into the barrel stand.
General Assembly Notes

**Gluing PVC:**
To join a pipe and a fitting:
- First clean and dry the surfaces that will be in contact.
- Apply the PVC primer to both surfaces. (This important step cleans them further.)
- Then apply the glue. When joining two parts, the glue needs to be applied to both the pipe and the fitting on the surfaces that will be in contact.
- Once the glue has been applied to both surfaces, quickly assemble two parts. Work carefully but quickly since the glue dries rapidly.
- Finally, twist the pipe in the fitting to spread the glue evenly between the two parts.

**Flaring Pipe:**
One pipe is flared in order to join to another pipe and contain a check valve in between them.
- Use a torch to heat the end section of the pipe (generally 2”). It is better to apply the heat to the outside of the pipe first rather than the inside, so that the inner walls do not collapse before the outside is soft. Avoid applying excessive heat to one area; this will cause brown burn marks. Also, remember that the fumes are toxic. (Work in well-ventilated areas.)
- Once the piece is bendable, stretch the edges of the heated piece around the outside of another piece of PVC. Use a flathead screw driver to help lift the heated piece over the other pipe.
- Make sure the two pieces of pipe are aligned in such a way that the flare is straight and overlaps at least 1.25”.
- Once the pipes are together and aligned properly, allow the section to cool with the second piece of PVC still inserted. Make sure to rotate the second piece inside of the cooling piece to make sure that they do not get too tight.

**Flattening PVC:**
- Cut a 12” length of 4” diameter PVC
- Cut in half lengthwise
- Using a torch or placing in an oven (at 350° for 10 minutes), heat the pipe while applying pressure with a flat weight to flatten it.

**Cutting Discs for valves:**
- Use a flattened sheet of PVC
- Use the appropriate sized hole saw (dimensions given on hole saws are larger than the disc produced because of the wall thickness of the hole saw)
- Lay out the hole configuration for the disc that you are going to cut (locate the centers of all holes that will be drilled in disc)
- Drill each of the outer holes before using the hole saw
- Use hole saw to cut out the disc
- Use a utility knife or file to trim the disc to the proper outer diameter