

2013

TEAM
ROPE
PUMP



ROPE PUMP
INSTRUCTION MANUAL
FIRST EDITION

MSU ROPE PUMP TEAM 2013

CONTENTS

HOW IT WORKS

Page 2

PUMP SPECIFICATIONS

Page 6

BUILD INSTRUCTIONS FOR ROPE PUMP ASSEMBLY

Page 7

BUILD INSTRUCTIONS FOR GUIDE BOX ASSEMBLY

Page 13

BUILD INSTRUCTIONS FOR BIKE DRIVE ASSEMBLY

Page 21

BUILD INSTRUCTIONS FOR ROPE & SEALS
ASSEMBLY

Page 27

MAINTENANCE

Page 12, 20, 33

ACKNOWLEDGEMENTS

Page 35

THE DREAM TEAM

Page 36

HOW IT WORKS

A rope pump is a simple device constructed of basic materials that pushes water from the bottom of a well using rope with seals attached to it.

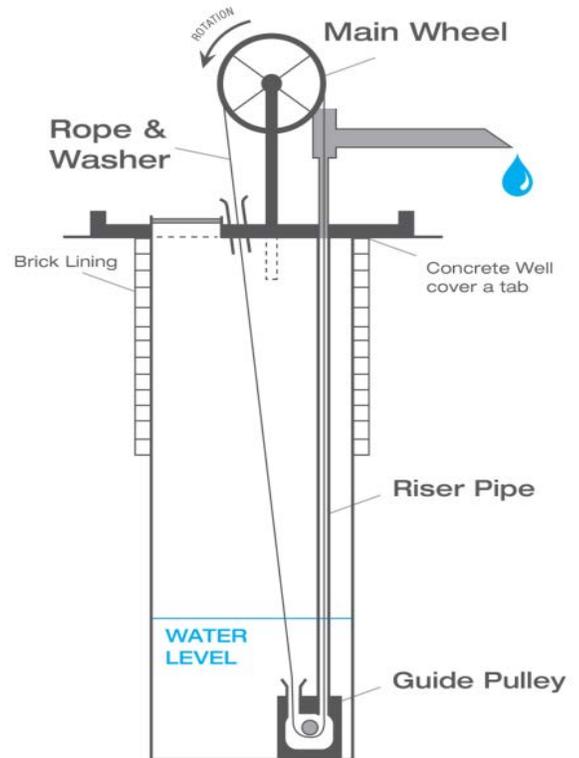
A rope pump works by creating a seal inside the riser pipe and pushing the water upward. The type of seal (knots tied by hand or seals that were cut out) will determine the efficiency of the pump.

When the drive wheel is turned friction will allow the rope and seals to travel up from the riser pipe and down into the well.

Once inside the well the seal travels the length of the well down to the guide box. The purpose of the guide box is to redirect the rope going down into the well back upward into the riser pipe. A guide box can be made in many different ways and with various materials.

After the seals travel through the guide box they enter the riser pipe. As the seals enter the riser pipe there is a water level between the bottom of the riser pipe and the surface water level which becomes trapped and forced upward.

Water is pushed the up entire length of the well by these seals until it reaches the top where an out spout is attached. This sudden opening allows the contained water to flow out into an awaiting bucket. Also the continued and enlarged riser pipe above the out spout allows air flow which drains the water through the out spout quicker.



Seals continue out of the top of the riser pipe and are grabbed by the wheel again due to friction. Then the whole process repeats.

PARTS OF A ROPE PUMP

Rope

Rope comes in many sizes, materials, colors and with many different properties. The important thing about rope for a pump application is its water absorption and its elasticity.



Strength is not an issue because it is extremely rare for a pump rope to handle more than 10 pounds.

Elasticity is important because a rope that will stretch when under a working load or when wet will decrease the tension, therefore limiting the necessary friction with the drive wheel.

Absorption is critical for two major reasons. The first being sanitation and prevention of bacterial growth. A rope that absorbs water may stay wet for extended periods of time, allowing for bacterial growth. The second reason is because of the added pumping weight that should be avoided.

Piping

The piping is used as the cylinder in the piston cylinder concept of the rope pump design. As the rope (with some sort of seals) passes upward through the pipe, the trapped water is forced to ground level and exits via the out spout.



Drive Wheel

The drive wheel is an essential part of a rope pump. This is the mechanism that rotates the continuous loop of rope through the system. By utilizing friction on the wheel the rope circulates down through the well, in and out of the guide box and up through the riser pipe, which pushes the water towards the earth's surface. A drive wheel can be made of anything. Our team found it very feasible to utilize an old bike rim due to its availability and ease of adaptability.



Traditional Wheel Guide Box

It is very common for a traditional rope pump to utilize a similar wheel as the drive wheel as the guide box down in the bottom of the well. A wheel is great because the rope can rotate the wheel and turn 180 degrees to be entered into the riser pipe with little or no friction. The down side is the extreme difficulty of installation, requiring someone to be underwater in a well to secure the wheel.



PVC Guide Box

Above are pictures of our team's innovative PVC guide box. There have been some similar ideas, and we have combined all the great ideas into one guide box. This is made of only PVC piping and pipe cement (disregard the metal strap which was installed for model scale purposes only). There is a flared inlet for the downward rope that guides the rope around a central grooved guide pipe and back up into a flared outlet that can be cemented onto the bottom section of pipe in the well.



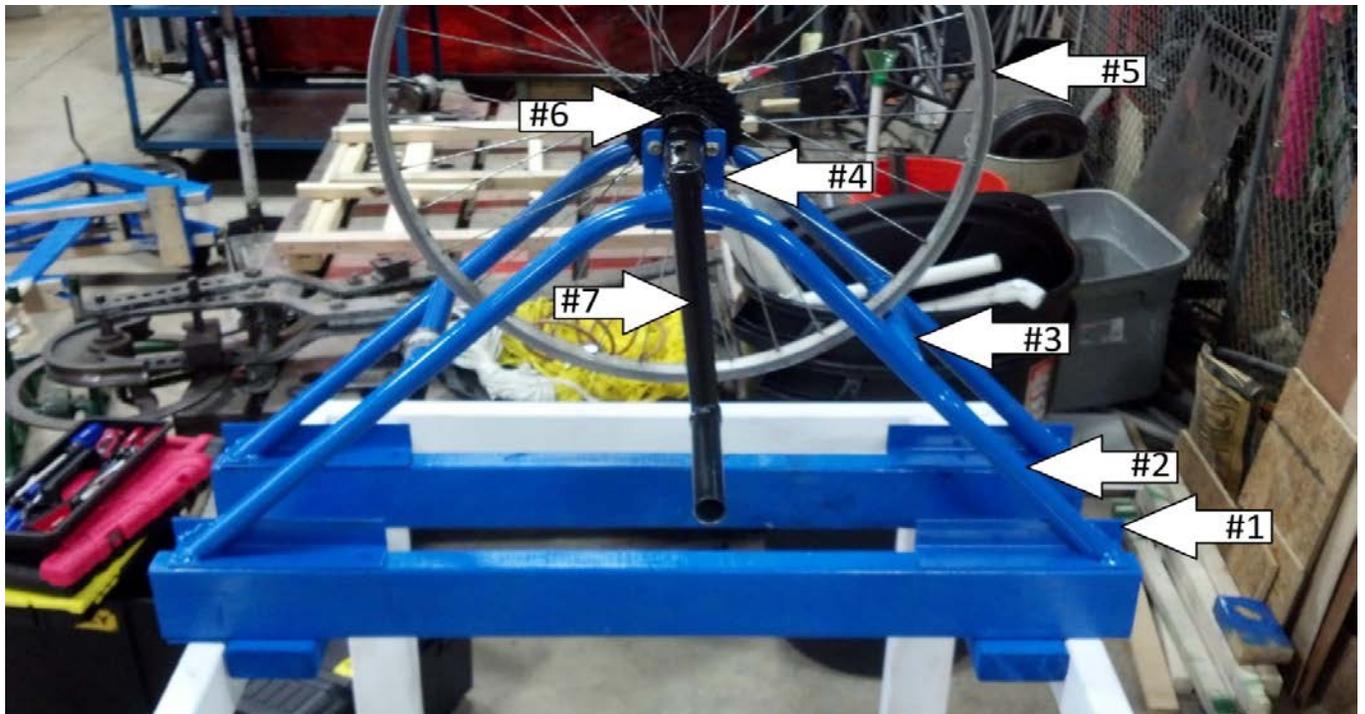
PUMP SPECIFICATIONS

The table below shows the recommended pipe diameter for a specific well depth. Please reference the table before installing your pump.

Depth (ft)	Recommended Pipe	Recommended Rope	Inner Diameter (inches)	Volume of water (ft ³)	Volume of rope (ft ³)	Total Volume (ft ³)	Total Weight (lbs)
3.2808	1-1/2" SCH 40 PVC	1/4" PP	1.610	0.0464	0.0011	0.0453	2.8259
6.5617	1-1/2" SCH 40 PVC	1/4" PP	1.610	0.0928	0.0022	0.0905	5.6518
9.8425	1-1/4" SCH 40 PVC	1/4" PP	1.380	0.1022	0.0034	0.0989	6.1730
13.123	1-1/4" SCH 40 PVC	1/4" PP	1.380	0.1363	0.0045	0.1318	8.2306
16.404	1" SCH 40 PVC	1/4" PP	1.049	0.0985	0.0056	0.0929	5.7976
19.685	1" SCH 40 PVC	1/4" PP	1.049	0.1181	0.0067	0.1114	6.9571
22.966	1" SCH 40 PVC	1/4" PP	1.049	0.1378	0.0078	0.1300	8.1166
26.247	3/4" SCH 40 PVC	5/32" PP	0.824	0.0972	0.0035	0.0937	5.8501
29.528	3/4" SCH 40 PVC	5/32" PP	0.824	0.1094	0.0039	0.1054	6.5814
32.808	3/4" SCH 40 PVC	5/32" PP	0.824	0.1215	0.0044	0.1171	7.3126
36.089	3/4" SCH 40 PVC	5/32" PP	0.824	0.1337	0.0048	0.1288	8.0439
39.37	1/2" SCH 40	5/32" PP	0.622	0.0825	0.0052	0.0773	4.8258
42.651	1/2" SCH 40	5/32" PP	0.622	0.0894	0.0057	0.0837	5.2280
45.932	1/2" SCH 40	5/32" PP	0.622	0.0963	0.0061	0.0902	5.6301
49.213	1/2" SCH 40	5/32" PP	0.622	0.1032	0.0066	0.0966	6.0323
52.493	1/2" SCH 40	5/32" PP	0.622	0.1101	0.0070	0.1031	6.4344
55.774	1/2" SCH 40	5/32" PP	0.622	0.1169	0.0074	0.1095	6.8366
59.055	1/2" SCH 40	5/32" PP	0.622	0.1238	0.0079	0.1159	7.2387
62.336	1/2" SCH 40	5/32" PP	0.622	0.1307	0.0083	0.1224	7.6409
65.617	1/2" SCH 40	5/32" PP	0.622	0.1376	0.0087	0.1288	8.0430

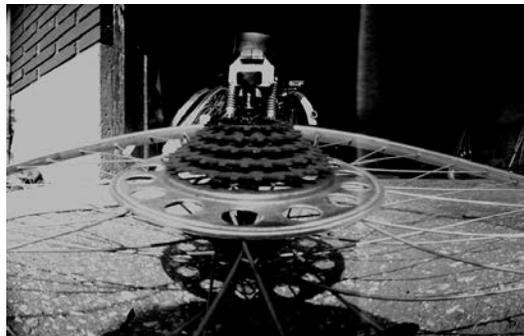
BUILD INSTRUCTIONS FOR ROPE PUMP ASSEMBLY

The Rope Pump



MATERIALS NEEDED

1. 12' length Steel tubing with diameter of 1"
2. 2' length angle iron
3. Bike rim with included gears
4. Steel plate 0.25" thick
5. Aluminum round stock 2" diameter
6. Various bolts
7. Grease



EQUIPMENT & TOOLS NEEDED

1. Welder
2. Saw able to cut metal
3. Bucket
4. Screwdriver or drill
5. Measurement device
6. Knife
7. Hammer or other heavy object



BUILD INSTRUCTIONS

- 1) Take the 12' steel tubing and cut it into two 5' parts plus two 6" parts and one 1' parts.
- 2) Bend the two 5' parts at a 90 degree angle and smooth off the ends to form the two arches of the pump (#2 in the picture).
- 3) Cut the angle iron into 4 parts that are 6" in length (#1).
- 4) Weld the angle iron to the arches like the picture shown (#1).
- 5) Measure out and cut two steel plates that are 4" by 3".
- 6) In one of the plates drill a quarter inch hole in the center of the plate one inch from the edge. In the other cut out a half circle large enough to fit the pipe (#4).
- 7) Weld the two plates at the center of the arches so they line up to accept the bike rim and allow it to spin (#4). You may need to set the rim in place for to line everything up.
- 8) Next drill a 1.15" hole in the center of the aluminum stock using a drill. Cut the stock so it is an inch thick and drill two holes, on either side of the large center hole, a quarter inch bit. Thread these two holes so they accept bolts (#6).

- 9) Take the two 6" cut steel tubes plus the 1' part and weld them together in an "S-like" shape similar to the picture shown to create the handle. Attach this to the rim with either a bolt (for easy removal) or through welding (for permanent fixtures) (#7).
- 10) Place the bike rim in between the plates and bolt down one side (#5). On the other place the aluminum stock on the handle side and bolt it to the other steel plate. Attach the handle and tighten everything down. This will form the pump assembly.
- 11) If needed take additional piping and brace the two arches to each other (#3).
- 12) Bolt the above assembly to an existing frame to bring the pump to shoulder level.
- 13) Start pumping water 😊

NOTE: Any/all dimensions are subject to change depending on the application and location of rope pump. Also, any methods, tools, or procedures followed may be changed to accommodate the circumstances.

MAINTENANCE FOR ROPE PUMP

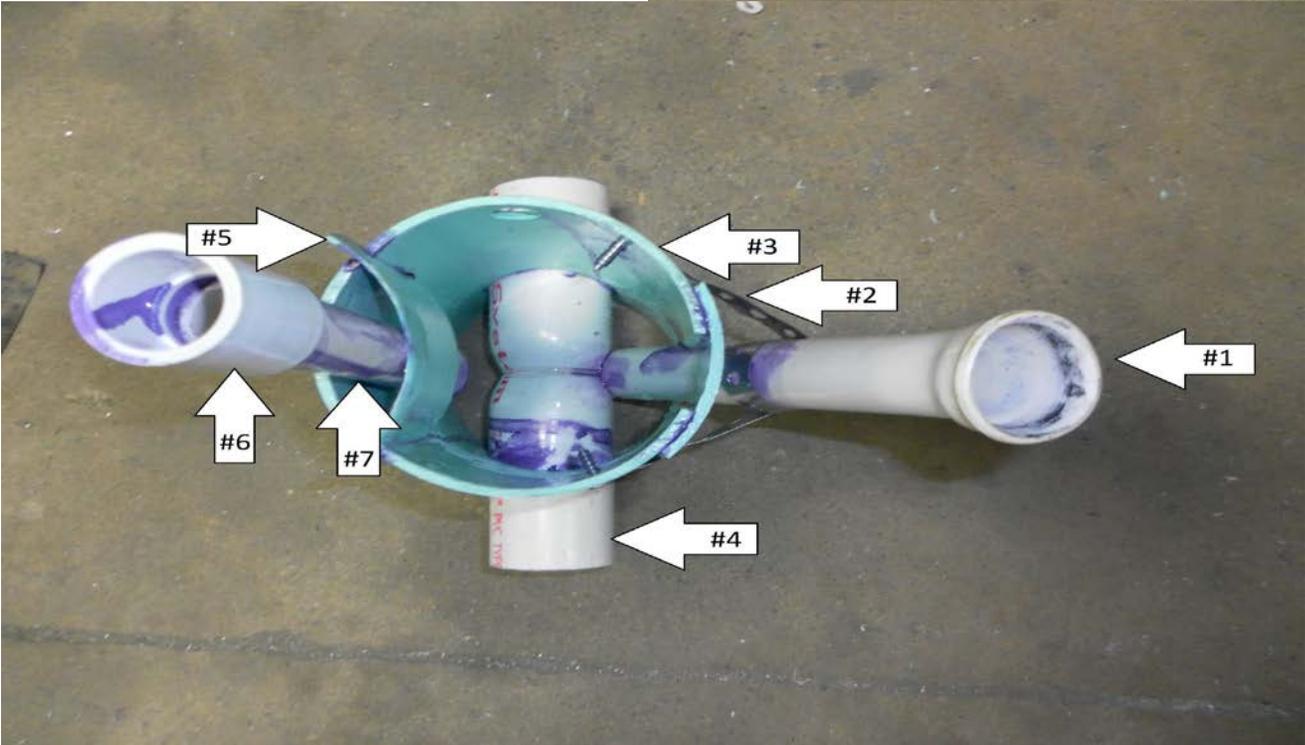


The only part of the pump requiring maintenance would be the rotating rim, gears and handles.

On a monthly basis these parts should be inspected for fatigue and grease applied to help reduce friction and make the turning of these components easier. Also keep a look out for any rust which can be fixed by sanding and repainting.

BUILD INSTRUCTIONS FOR GUIDE BOX ASSEMBLY

The Guide Box



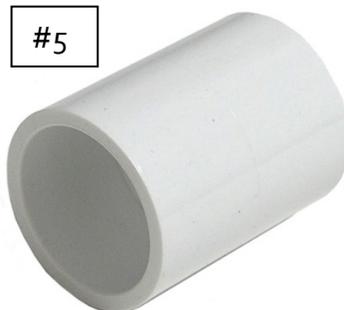
EQUIPMENT & TOOLS NEEDED

1. Welder
2. Saw able to cut metal
3. Bucket
4. Screwdriver or drill
5. Measurement device
6. Knife
7. Hammer or other heavy object



MATERIALS NEEDED

1. 12" length of large PVC pipe with diameter at least 4"
2. 10" length of PVC pipe with diameter 2"
3. 10" length of PVC pipe with same diameter as rising pipe (see pipe diameter vs. well depth chart in previous section)
4. 10" length of PVC pipe with slightly larger diameter than rising pipe
5. PVC coupler fitting – sized to fit rising pipe
6. PVC primer and cement
7. Small cone shaped object (soda can cut down the middle and wrapped and taped works great!)
8. Steel cable or heat resistant rope
9. Heat source



BUILD INSTRUCTIONS

- 1) Take the steel cable and wrap it around the center of the 2" diameter PVC pipe. Heat the PVC pipe with available heat source until the plastic starts to become pliable. As the plastic softens, slowly tighten the steel cable around the PVC pipe creating an indent around the center. Once desired depth of groove is obtained (about 1/2" deep), remove heat source and allow cooling and hardening of the PVC pipe. Now remove the steel cable. This is item #4 in the picture above. Set this item aside.



- 2) Locate the large 4" diameter PVC pipe section (#3 in picture). Using a saw or drill, cut a 2" a circular hole leaving about 1" of clearance from the bottom of the large PVC pipe. Cut an identical hole across from the new hole on the opposite side. Now insert the grooved 2" diameter PVC pipe through the cut holes in the large PVC pipe. Using PVC primer and

cement, secure in place such that the groove is in the center of the large PVC pipe. Allow to dry completely.



3) Locate 10" length of PVC pipe with same diameter as rising pipe. Using PVC primer and cement, secure the coupler (#6 in picture) to one end of the rising pipe (#7 in picture). Allow to dry completely.

4) Take PVC pipe with attached coupler (#6 & #7 in picture) and flare the end that does not have the coupler. Using available heat source, heat up this end of the PVC pipe until the plastic become soft and pliable. Slowly insert the cone shaped object into the heated end of the pipe. This should slightly expand the end of the pipe, creating a flare effect. Once desired flare is achieved, remove the heat source and allow cooling and hardening of the PVC pipe. Remove the cone shaped object. Now position it perpendicular to the grooved 2" diameter pipe along the wall of the large PVC pipe as shown. Leave a 1" gap between the bottom of the rising pipe and the grooved guide pipe. Using PVC primer and cement, secure in place. Allow to dry completely.



- 5) For extra security, a brace may be added to the rising pipe secured in step #4. This is done using a small section of the large PVC pipe. Using a saw, cut a short curved edge from the large PVC pipe (#5 in picture). Secure using PVC primer and cement around the open side of the rising pipe as shown above. Allow to dry completely.

- 6) Locate the 10" length of PVC pipe with slightly larger diameter than the rising pipe. This is the guide box's inlet pipe (#1 in picture). Using available heat source, heat up one end of the PVC pipe until the plastic become soft and pliable. Slowly insert the cone shaped object into the heated end of the pipe. This should slightly expand the end of the pipe, creating a flare effect. Once desired flare is achieved, remove the heat source and allow cooling and hardening of the PVC pipe. Remove the cone shaped object.



- 7) Taking this flared PVC pipe from step #6, secure it perpendicular to the 2" guide pipe along empty the wall (across from the rising pipe) of the large PVC pipe as shown. Leave no gap between the bottom of the inlet pipe and the guide pipe. Secure using PVC primer and cement. Allow to dry completely.
- 8) For extra security, follow step #5 on the inlet pipe (#1 in picture). Allow primer and cement to dry completely. The securing process can also be done using a steel band and screws (#2 in picture) as shown on the right hand side of the guide box.



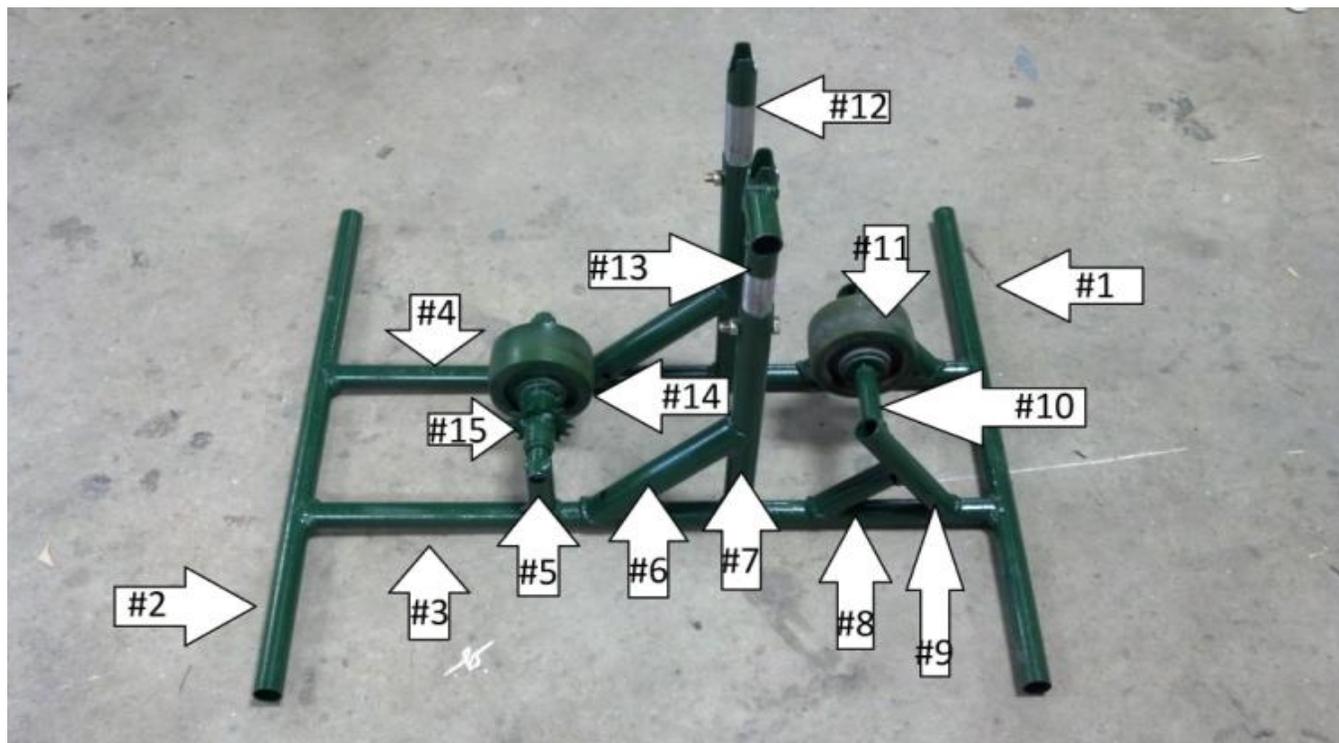
NOTE: Any/all dimensions are subject to change depending on the application and location of rope pump. Also, any methods, tools, or procedures followed may be changed to accommodate the situation.

Maintenance

Little to no maintenance is required on the guide box. All PVC components of the guide box will have a usable lifespan of 8-10 years. After this 10 year period, a new guide box should be constructed and installed. During the guide box's usable lifespan of 8-10 years, all glued components should be checked for security and placement on a yearly basis. If any components are loose or have shifted, reinforce and secure using additional PVC cement or bracing. If the rising piping is ever replaced or repaired, check the guide box as it attached to the bottom of the rising pipe. Perform any repairs or replacement if necessary.

BUILD INSTRUCTIONS FOR BIKE DRIVE ASSEMBLY

Bike Drive Option



Equipment and Tools Needed

- 1 Welder
- 2 Saw able to cut metal
- 3 Bucket
- 4 Measurement device
- 5 Drilling device and drill bits



Materials Needed

1. Mild Steel Tubing
2. 2 Wheel Caster or some sort of small wheel with bearings
3. 1 Chain Sprocket
4. Two pins or bolts
5. 4 Large washers
6. Solid Steel Rod



BUILD INSTRUCTIONS

1) First cut the steel tubing to form pieces #1 and #2 to start making the base frame. These pieces are 22" long.

2) Next is to cut pieces #3 and #4 at 24" long.

NOTE: If a perfect fit is desired between tubes then notch the mating ends to fit onto the diameter of another tube. A "V" notch is the simplest and a "U" notch will give a near perfect fit.

3) Place tubes #3 and #4 about 11" apart facing the same direction.

4) Put tubes #1 and #2 in the opposite direction of #3 and #4, with one at each end.

5) Weld both ends of #3 and #4 to the joining tubes #1 and #2.

6) Piece #5 comprises of identical tubes on both sides which are used as vertical supports for the drive wheel. These are cut at 6" long and welded 9" from one end of the frame.

7) Next is tube #7 which is the vertical support for the bike frame. This also has an identical tube on the opposite side of the frame. The #7 tubes are cut at 8" long and have a hole drilled 1.5" from one end. The vertical support is welded vertically (with the hole on top) at a distance of 8" from the #5 tubes.

8) The #6 tubes are the supports for #7 tubes. These are 6" long and are welded at a 45 degree angle between the upright #7's and the frame base.

- 9) Tubes #8 and #9 both have identical tubes on the opposite side and are to be welded 90 degrees apart from each other. Tube #8 is 4" long and tube #9 is 7" long. Once the 90 degree weld has been made then weld onto the frame base a distance of 2" from the bike frame vertical supports.
- 10) Next is to assemble the idler wheel axle. This consists of a solid steel bar (#10) of length 11" with a wheel of choice (#11) positioned between two washers which will be welded.
- 11) The idler wheel should be positioned 2" from one side of the steel bar (not centered). A large washer will be placed on each side of the wheel with some space and welded to the axle (#10). This keeps the wheel from sliding left and right on the axle shaft (#10).
- 12) Now the axle shaft assembly can be welded to tubes #9 which are already welded to the base frame. Be sure to weld the axle as level as possible.
- 13) Tube #12 is the inside support for the bike frame. It is 11" in length. This piece must have a "U" or "V" notch in it to fit the frame inside.
- 14) Tube #13 is an "L" shape inside support for the bike frame. This shape allows the support to go up and around the bike chain to hook under the rear frame of the bike. The support is 11" tall with a 3" wide horizontal piece welded on and another 2" vertical support piece welded on. This last piece must have a "U" or "V" notch in it to fit the frame inside.

- 15) Both inside support tubes for the bike frame will need a hole drilled in it once the entire bike mount is completed. A pin will go through here to hold the adjustable riser. As many holes as needed may be drilled to accommodate different size bikes.
- 16) The last part is the drive wheel axle assembly. This consists of a solid steel shaft, 2 large washers, a small chain sprocket, and a wheel which may or may not be the same as #11.
- 17) The wheel should be positioned 2" from one side of the steel bar axle (not centered). A large washer will be placed on each side of the wheel with some space and welded to the axle. This keeps the wheel from sliding left and right on the axle shaft.
- 18) Lastly weld the bike sprocket on the side of the axle with more space and center it within this gap. Now the drive wheel assembly can be welded onto its vertical tubes #5.
- 19) The final step for the drive wheel assembly is to place the bike on the mount and lift the inside support tubes #12 and #13 until they are cupping the frame. Mark the inside support with a writing utensil through the hole that was drilled in the main bike frame support tube #7's. This is where a pin will be inserted to support the bike frame while the bike mount is in use.
- 20) More holes can be drilled in the exact same manner for different sized bikes.
- 21) Now you may paint your bike mount any color you desire to prevent rust and increase the life span.

BUILD INSTRUCTIONS FOR ROPE & SEALS ASSEMBLY

Rope & Seals



EQUIPMENT & TOOLS NEEDED

1. Punch, Knife, or Scissors
2. Hammer
3. Lighter or flame source



Materials Needed

1. 5/32" Rope (Polypropylene, polyester, metal cable, hemp rope, etc.)
2. Rubber (i.e. rubber sheet, flip-flop, Rubber siding, Rubber for water sealing on showers)
3. 5/32" washers

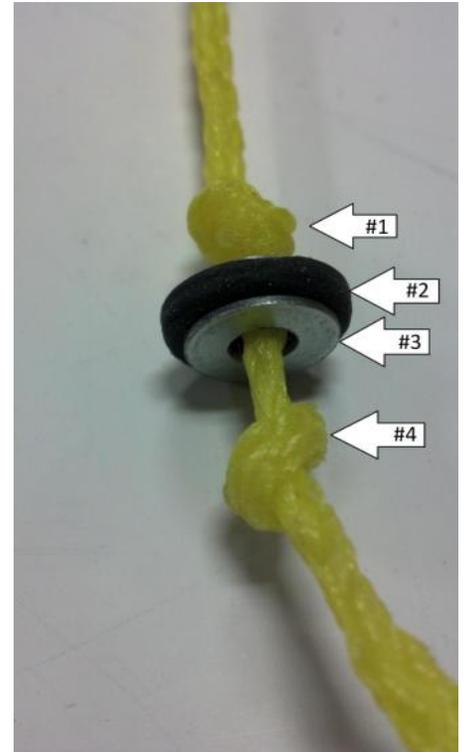


BUILD INSTRUCTIONS FOR SEALS

- 1) The first step is to make the seals. Place the rubber sheet onto a piece of wood and put the punch onto the rubber.
- 2) Once the punch is in place hit the punch with your hammer.
- 3) Remove the punched out seal from the punch
- 4) Repeat this until the desired amount of seals has been made.
- 5) After the seals have been punched out, punch out a $\frac{5}{32}$ " hole in the middle of each rubber seal.
- 6) After creating the holes on the seals you are now ready to put the seals onto the rope.

ASSEMBLY INSTRUCTIONS FOR ROPE + SEALS

- 1) Begin by tying a knot at the end of the 5/32" Polypropylene rope. (#1)
- 2) Slide a 5/32" washer onto the opposite end of the rope where you tied it (#2)
- 3) Then slide on a rubber seal that you made previously (#3)
- 4) Next slide on another 5/32" washer (#4)
- 5) Repeat sequences B-D until the desired amount of seals are on the rope.
- 6) Once the seals and washer are on the rope slide one set (washer-Seal-Washer) down onto the knot you created.
- 7) Tie a second knot after the seal and try to get knot as close as you can to the end of the one set (#5)
- 8) Next tie a knot 3.5 ft. or 1 meter away from the last knot and tie another knot. (#1)
- 9) Repeat instructions F-H until the desired length of rope is achieved.



Materials Needed to Assemble Connection of Rope + Seals to Rope Pump

1. Previously knotted rope with seals on it
2. ½" PVC Pipe
3. ½" PVC Pipe Couplers



Assembly Instructions for Connection of Rope + Seals to the Rope Pump

- 1) Tie one end of the old rope to the pump structure.
- 2) The rope needs to be fed around the bottom guide box until the rope comes out and both ends are visible.
- 3) Then feed the rope through the entire pipe that is going to be lowered into the well (it is easier to feed the rope through one section of pipe at a time).

- 4) The rope should then carefully be untied from the pump structure.
- 5) Now the rope can have its free ends tied together with enough tension to stay on the drive wheel.
- 6) To get the desired tension, find where the rope is tight around the wheel and marking those spots on the two ends of rope.
- 7) Then take the two ends of rope off of the wheel and pull the rope slightly tighter.
- 8) Tie the two ends together by creating a double knot with the two ends.
- 9) Once the knot has been made have one person pull on the two ends to make sure the knot is tight and the other person to burn the knot using the lighter for about 4 seconds on each side of the knot (this is to ensure the knot does not come undone.
- 10) Once the two ends have been fused together, place one part of the rope on one side of the wheel and begin to rotate the wheel in order to get the rope around the wheel.

Maintenance

Throughout the use of your new rope pump some routine maintenance may need to be performed. However due to the simplicity of the pump very little maintenance is required.

- 1 Due to the friction involved, wear and tear might be seen in the rope and seals. Special attention should be paid to the rope during each use for fraying or any areas of damage. Polypropylene ropes should be replaced on a yearly basis or until signs of wear appear. When the rope is replaced, it is recommended to also put new seals on, especially the rubber part.

To replace the rope:

- a The original rope must be cut
- b Tie one end of the old rope (still in the well) to the pump structure
- c Tie the other end of the old rope to the new replacement rope
- d Tie the other end of the new rope to the pump structure as well (this is a safety measure so the rope does not get pulled all the way through).
- e The new rope needs to be tied to the old one and fed around the bottom guide box by pulling the old rope (the end tied to the pump structure) until the new rope comes out and both ends are visible.
- f The new rope should then carefully be untied from the pump structure and from the old rope.

- g Now the replacement rope can have its free ends tied together with enough tension to stay on the drive wheel.
 - h With this new rope, new seals should be applied.
- 2 Damaged seals will only slightly affect the overall performance of the pump and shouldn't be a concern to the average user. Seals cannot effectively be replaced individually. Users can replace the rope and put on new seals if bad seals are hurting the pump performance.
- 3 All rotating parts at the head of the pump should be cared for using grease in any high friction areas - like the handle and the bearings in the wheel. This will make it easier for the user to pump water and turn the drive wheel.

ACKNOWLEDGEMENTS



Dr. Thompson- Our team's professor and advisor for the ME 478 Product development class at MSU that spawned this project entirely.

Dr. Flores- As the team's primary advisor and source of international knowledge, he has helped us vastly in the design process and in decision making along the way. His background of Guatemala and knowledge of agriculture have greatly helped us.

Dr. Blake-The Director of International Studies at MSU who advised our team early on in the project and shared his wisdom of Latin America with us.

Carolyn McLean- Our awesome graphic designer who created the team logo and assisted in other design as well as photography.

Mary Anne Walker- Publicity and diffusion for the betterment of our project

THE DREAM TEAM

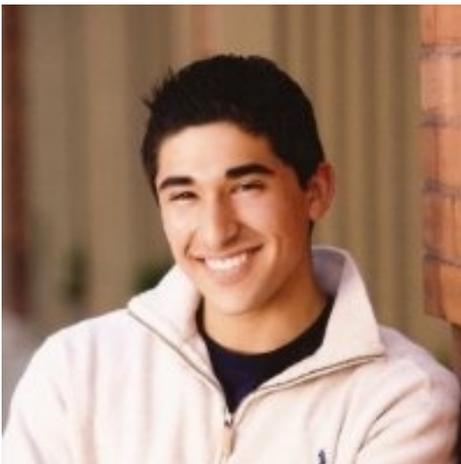
OUR INTEREST: GIVING LIFE

Tyler Rumler



- ✚ Hometown: Blissfield, MI
- ✚ Major: Mechanical Engineering
- ✚ Class: Senior
- ✚ Interests: automobile, Fixing Things, Outdoors, fishing, wood working

Jonathan Shapiro



- ✚ Hometown: Grand Rapids, MI
- ✚ Major: Mechanical Engineering
- ✚ Class: Senior
- ✚ Interests: Automotive, Building/Fixing, Outdoors, Golf

Austin Tokarski



- ✚ Hometown: Kalamazoo, MI
- ✚ Major: Mechanical Engineering
- ✚ Class: Senior
- ✚ Interests: Baja, Football, Cooking, Automobiles, Anything Outdoors

Daniel Kenny

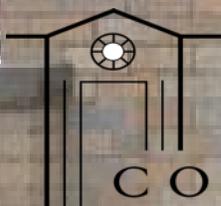
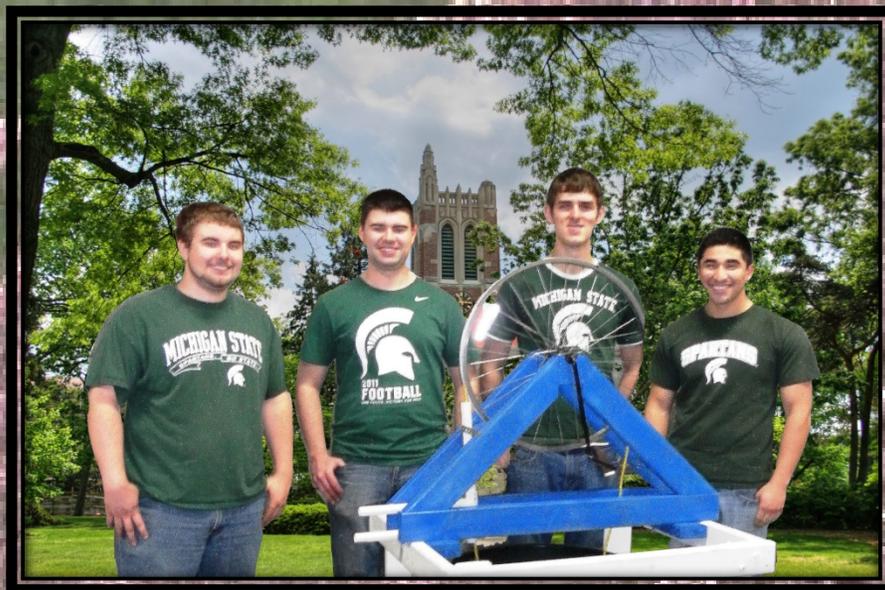


- ✚ Hometown: Troy, MI
- ✚ Major: Mechanical Engineering
- ✚ Class: Senior
- ✚ Interests: Traveling, Gadgets, Fixing Things



MICHIGAN STATE UNIVERSITY

TEAM ROPE PUMP



COLLEGE OF
ENGINEERING



LEARN MORE ON THE WEB @ <https://sites.google.com/site/msuropepumteam/home>