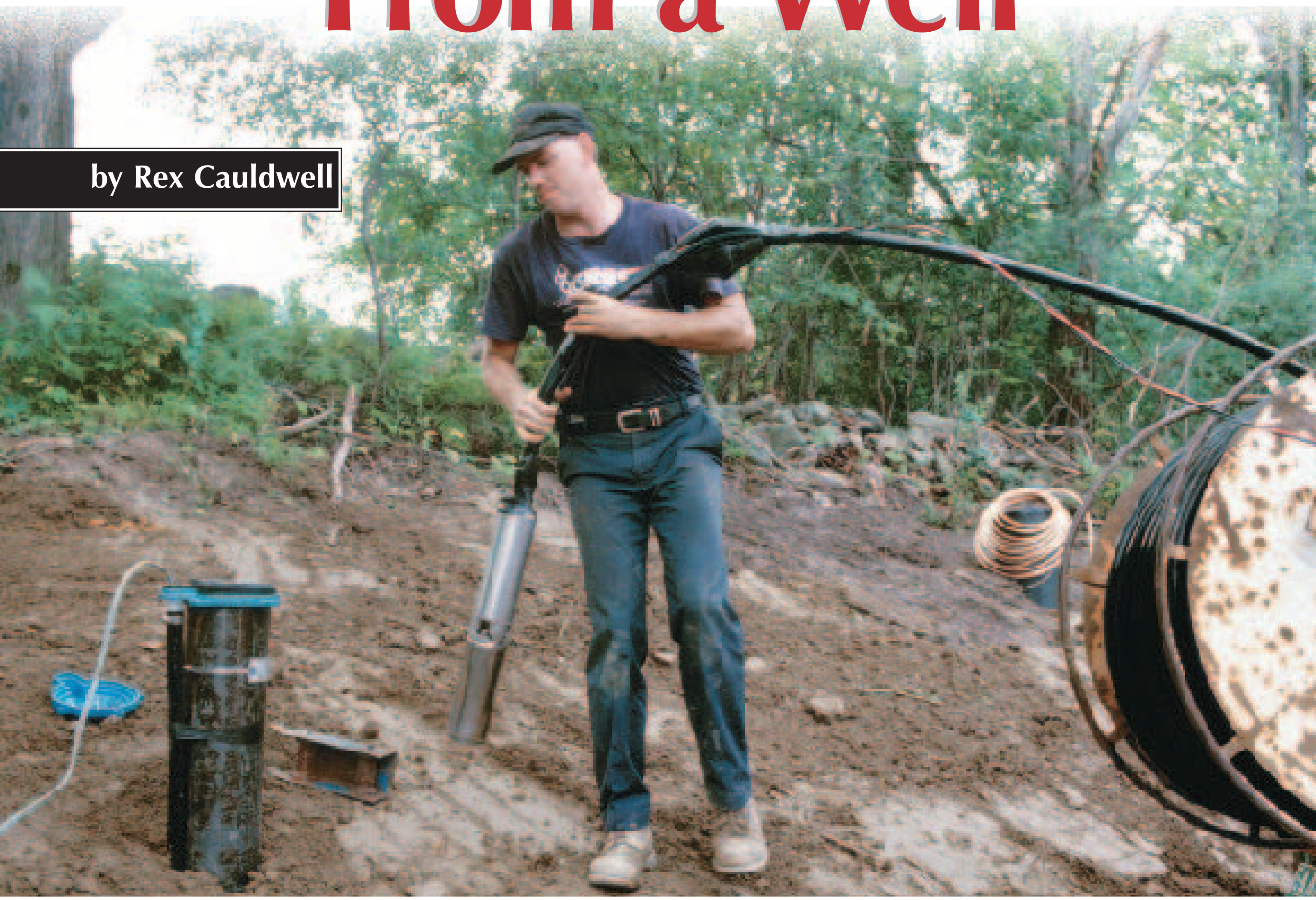
Getting Water From a Well

by Rex Cauldwell



Consider drought conditions when sizing the pump and don't scrimp on the fittings

Most people with a municipal water service take water for granted. Turn on the faucet, and out comes a never-ending stream from the water utility. Not so in the country — it takes a lot of work and money to get water. And even then, the water comes from a small water pressure tank within your house, and you have a limited amount. To understand how a well system works, let's start at the tank.

The tank is not filled to the top with water. If it were, you would get nothing out of the faucet. Because water will not compress, it's the air trapped above the water within the tank that pushes the water out.

Originally, tanks were made from steel and were nothing more than a cylinder. As the water entered the bottom of the tank, the air inside rose and became compressed. When you turned a spigot on, the compressed air pushed the water out of the tank toward the open faucet. As water left the tank, there was more room for the air, and thus the pressure lowered. When the pressure went down to 20-30 pounds, a pressure switch would turn on

Figure 1. New and old pressure tanks are shown side by side. The new tank has a bladder to keep the air charge from dissolving into the water.

Figure 2. This tank T is a specialty manifold for the many connections just before the tank. It includes ports for the pressure gauge, the pressure switch, a drain valve, and a pressure relief valve.

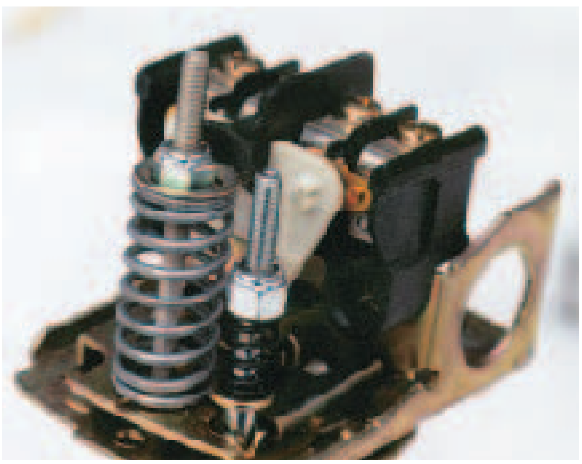


Figure 3. The pressure switch is the brain of the system. The tall screw shaft adjusts cut-in and cut-out pressure at the same time, keeping 20 pounds of pressure between the two. The shorter shaft is cut-out only. The wire terminals are in the background.

a pump, repressurizing the system. The pump would turn off when the pressure in the tank deactivated the pressure switch at about 50 pounds.

The old tanks eventually would run out of air as it gradually dissolved into the water. As the air was used up, the only thing creating the water pressure was the pump. So every time you opened a faucet, the pump would run, wearing out pump and controls and creating the dreaded "waterlogged" tank. You could tell when this was happening, because the water would start to pulsate as it came out of the faucet or shower.

This system is still in use today — with one big exception. Newer tanks have a bladder that keeps the air separated from the water (see Figure 1).

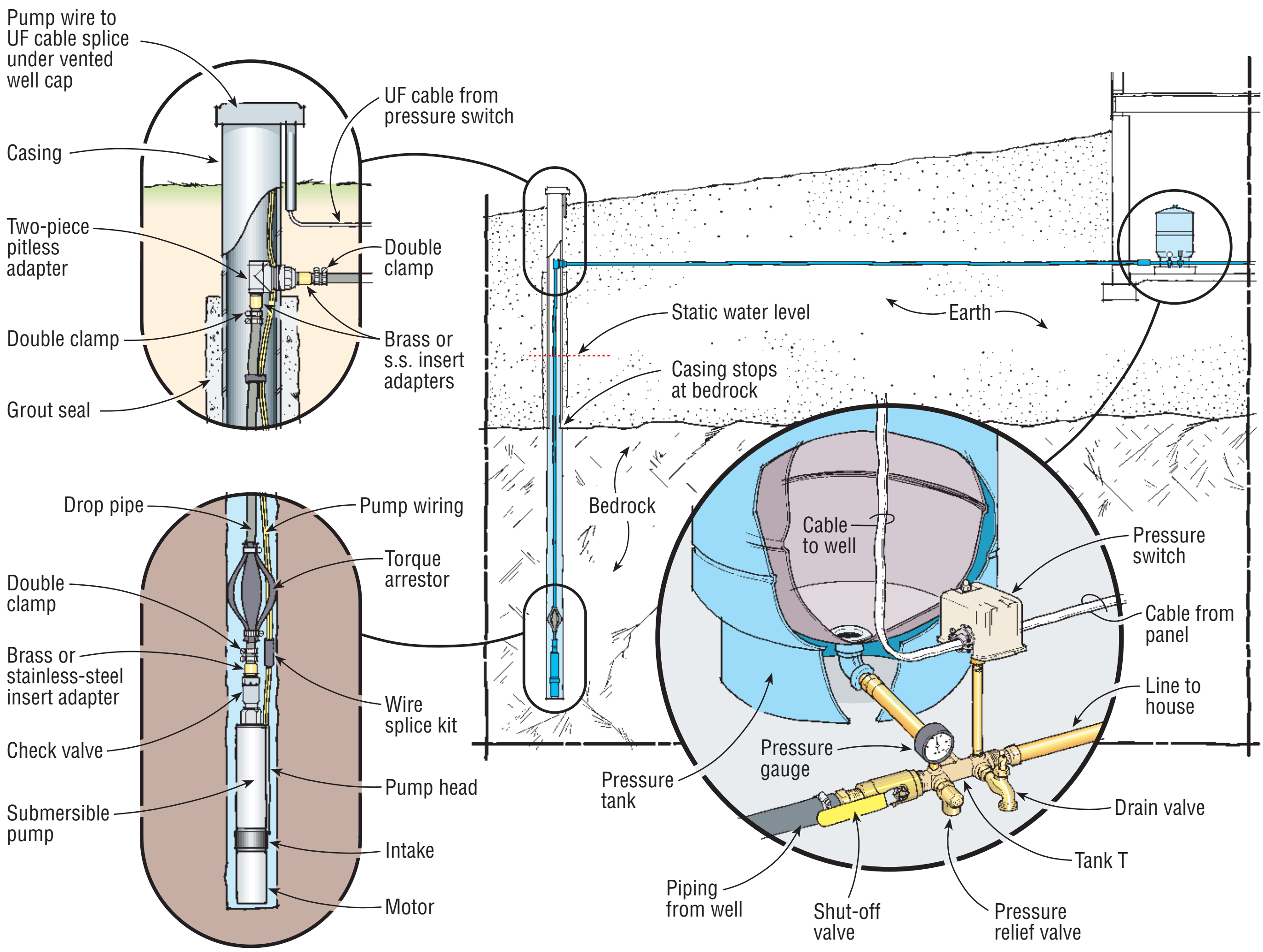
Quality Fittings

Today's water tank has two main pipes attached to it — incoming water from the well and outgoing water to the house. In addition, there is a house shut-off valve, a pressure gauge, a pressure switch, a pressure relief valve, and a drain valve. Connecting all of these takes a lot of fittings and time. To speed things along, a brass tank T was developed (some are made of copper, others of galvanized). This is a specialty manifold that has ports for all of the necessary fittings and the pressure switch. I usually assemble them ahead of time, which saves about an hour in the field (Figure 2).

The valve to the house must be a full-flow valve, which allows water to flow unrestricted. Other valves reduce water pressure and restrict the flow. This requirement limits you to a ball valve or gate valve. I always use an Apollo ball valve — nothing else. These are heavy-duty and expensive. Never use a gate valve — they cause too many problems, as do cheap ball valves.

The pressure switch. I always use a Square D switch. It allows easy adjustment of the water pressure and plenty of room for the wires. Pressure switches come set up for 20/40,

The Well System at a Glance



A good water well system uses the best fittings, a large pressure tank, and a pump big enough to deliver water when the level is low.

30/50, and 40/60. You can achieve higher pressures, but you'll need a heavy-duty switch and a larger tank. The lower figure is the cut-in pressure, and the higher figure is the cut-out pressure. But you can adjust to almost any pressure combination. Inside the pressure switch housing are two adjustment screws (Figure 3). Turning the nut on the tall screw shaft clockwise will increase the overall pressure at both the top end and the bottom end of the cycle. For example, you'll get 32/52, 34/54 as the nut tightens down on the spring. Never touch the nut on the short screw shaft unless you really know what you're doing; it's cut-out only.

The pipe to the pressure switch is a 1/4-inch I.D. pipe that takes the water from the big brass T and sends it to the pressure switch. Because this pipe has a small diameter, it can easily rust closed. When that happens, the pump can build up enough pressure to rupture the bladder and blow the water pipe right off the fittings. Or the faucet will simply not turn on. To avoid this problem, I use a 1/4x4-inch brass nipple for the connection; brass doesn't

Minimum Wire Size for Franklin Electric Motors

Two- or Three-Wire Cable, 60Hz (service entrance to motor — maximum length in feet)

Motor Rating			60°C Insulation — AWG Copper Wire Size												
Volts	**HP**	**KW**	**14**	**12**	**10**	**8**	**6**	**4**	**3**	**2**	**1**	**0**	**00**	**000**	**0000**
115	1/3	0.25	130	210	340	540	840	1300	1610	1960	2390	2910	3540	4210	5060
	1/2	0.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/3	0.25	550	880	1390	2190	3400	5250	6520	7960	9690	11770			
	1/2	0.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	0.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870		
	1	0.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520		
	1 1/2	1.10	190	310	480	770	1200	1870	2320	2850	3500	4280	5240		
	2	1.50	150	250	390	620	970	1530	1910	2360	2930	3620	4480		
	3	2.20	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610		
	5	3.70	0	0	**180**	280	450	710	890	1110	1390	1740	2170	2680	
	7 1/2	5.50	0	0	0	**200**	310	490	610	750	930	1140	1410	1720	
	10	7.50	0	0	0	0	**250**	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	**270**	340	430	530	660	820	1020	1260

Motor Rating			75°C Insulation — AWG Copper Wire Size												
Volts	**HP**	**KW**	**14**	**12**	**10**	**8**	**6**	**4**	**3**	**2**	**1**	**0**	**00**	**000**	**0000**
115	1/3	0.25	130	210	340	540	840	1300	1610	1960	2390	2910	3540	4210	5060
	1/2	0.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/3	0.25	550	880	1390	2190	3400	5250	6520	7960	9690				
	1/2	0.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	0.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870	9380	
	1	0.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520	7780	9350
	1 1/2	1.10	190	310	480	770	1200	1870	2320	2850	3500	4280	5240	6300	7620
	2	1.50	150	250	390	620	970	1530	1910	2360	2930	3620	4480	5470	6700
	3	2.20	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610	4470	5550
	5	3.70	0	**110**	180	280	450	710	890	1110	1390	1740	2170	2680	3330
	7 1/2	5.50	0	0	**120**	200	310	490	610	750	930	1140	1410	1720	2100
	10	7.50	0	0	0	**160**	250	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	270	340	430	530	660	820	1020	1260

1 Foot = .3048 Meter

Lengths not in red meet the U.S. National Electrical Code ampacity for either individual conductors or jacketed 60°C or 75°C cable.

Lengths in red meet the National Electric Code ampacity only for individual conductor 60°C or 75°C.

If aluminum wire is to be used, it must be two sizes larger than the AWG copper wire sizes shown.

Chart courtesy of Franklin Electric.

corrode like galvanized (Figure 4).

The water pressure gauge. Admittedly, I mostly use the same cheap gauge (around $5) that everyone else uses. It has a pretty short life span. A better gauge can be found for $15 to $25 from Grainger, and I typically use that on higher-quality custom jobs.

The Wiring

Whether the wire will be two-conductor with ground or three-conductor with ground will be determined by the type of pump motor — called two-wire or three-wire. In the old days, everything was three-wire, beginning at the control box where the starting capacitor, starting relay, and overload were located. You had a common, a start, and a run wire from there to the pump motor. Later designs put all this in the motor, so you had to run only two wires. For a 240-volt motor, this meant two hots and a return, just like any other 240-volt load.

Even today you have a choice. Since one is as good as the other, both two-wire and three-wire systems are common. An advantage of the two-wire system is that it's less expensive (there's less wire) and simpler to install (you don't have to worry about switching the run and start wires). The wire from the pump to the top of the wellhead is special submersible pump wire, listed just for this purpose. You cannot use this type of wire from the wellhead to the house — you must use UF wire. The UF wire goes all the way to the pressure switch. The most common question I'm asked about the wiring is how you make a splice work under water, where the motor wire connects to the submersible pump wire. The answer is that we use submersible splice kits. The wire is crimped together, and a heat-shrink sleeve goes over the crimp. Heat is applied to the sleeve, and it shrinks around the splice, making it watertight (Figure 5).

The gauge of wire you use depends on the distance to the pump and what its horsepower is, but I never use anything smaller than 12-gauge (see the chart at left).

Figure 4. This galvanized pressure switch pipe is completely blocked with corrosion. As a result, the pressure could build to disastrous results or the pump refuse to turn on at all. A brass nipple would have prevented this corrosion.

Figure 5. A submersible splice kit connects the pump motor to the submersible pump wire running to the wellhead (top). In the photo below, the shrink tube on the top has not been heated. The bottom wire shows how the tubing shrinks to form a watertight seal.

The Pump

A submersible pump has two main parts. The top part is the pumping mechanism — called the pump head. The bottom part is the motor. In between the two is where the water is sucked in (Figure 6, next page).

A submersible pump head is no more than a bunch of little stacked impeller stages. The water gets whirled around in one and thrown to the next. Each little impeller raises the water pressure a small amount. The more impellers, the more water pressure. Naturally, the deeper the well, the more impellers we need to get the water out. However, the more impellers needed, the greater the "drag," which means we have to keep increasing the horsepower of the pump motor.

Typically, a half-horse pump can take you down to around 140 feet, measured from the uppermost point to the pump. Sometimes an installer will cheat on a low-bid job. It's done this way: Let's assume the well is 300 feet deep. The pump is normally placed 20 feet off the bottom to allow for sediment to settle out. Technically, you're not pumping the water from where the pump is, at 280 feet. You're pumping the water from where the static water level is, the point at which the water comes up in the well. Let's say this is 50 feet below the surface. At 280 feet, you need a 1-horse pump. But to save money, the installer may use only a 1/2-hp pump, reasoning that the static level is at 50 feet. This is cheating, however, because the water level will drop — either during a drought or as additional wells are drilled in the area. When the water level in the well drops below 140 feet, water pressure will decrease noticeably, and eventually the pump may not work at all. So it's a good idea to ask your installer about the size of the pump; if you have doubts, take a look at the box to make sure you are getting what you're paying for.

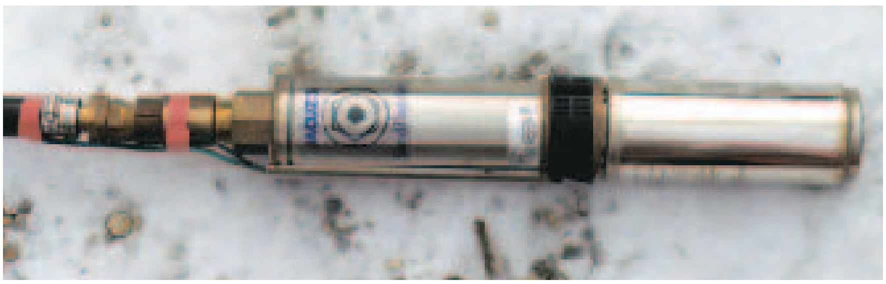


Figure 6. The lower part of the pump houses the motor, and the top half contains the pumping mechanism (the pump head). The plastic section between the two is the inlet for the water. The wires are secured to prevent chafing.

Figure 7. The two fittings on the left are the only ones you want to use. The others are guaranteed to break, crack, and split.

The Pipe

You have a choice of pipe: polyethylene (black rolled plastic), PVC, or galvanized. Many installers use the latter two so that the homeowner will not be able to pull the pump without the installer's special equipment. But without a doubt, polyethylene is the best pipe to install down to 500 feet. Because poly will stretch, you need to leave slack in the wire to allow for it. I normally leave 2 extra feet just below the well cap in the casing.

The pipe size is normally 1 inch — 3/4 is only for low-bid jobs. I rarely use anything bigger because the clamps don't hold so well. The pipe should be rated for 160-pound pressure. The words "water service pipe" should be printed on it. For deep wells at or around 500 feet, I use 200-pound rated pipe. The clamps must be stainless-steel marine clamps, not hose clamps. Beware: Some clamps that claim to be all stainless have only a stainless band; the screw housing may not be stainless.

The insert fittings are of primary concern for a long-lasting installation. Never use nylon or PVC fittings on poly — they break, crack, and split. Galvanized isn't much better, which leaves solid brass and stainless steel; I prefer the latter (Figure 7). A 1-inch poly to stainless-steel male adapter costs around $10; you will need four of them. That's $40 for just four fittings. Compare that to the $4 price tag for nylon fittings, and you'll see why I don't win low-bid jobs.

One problem with poly pipe is that

it will twist when the pump turns on and off. This twisting motion will rub the wire against the casing and well wall. It's worst for the first 20 feet up from the pump, but I've seen wear spots for over 100 feet. The solution is simple: Install a torque arrestor. This is a rubber device that squeezes against the walls of the well and prevents the motor torque from turning the pipe and/or chafing the wires (Figure 8).

Figure 8. This two-piece torque arrestor prevents the motor from chafing the wires as the pump turns on and off.

The Pitless Adapter

The pitless adapter is a special two-part fitting (Figure 9). One half connects to the pipe that goes down to the pump, and the other half goes through the casing and connects to the pipe that runs to the house. This fitting brings the line from the house into the well casing below the frost line, while allowing for removal of the pump. To pull the pump, you lower a homemade T-shaped tool into the well casing (Figure 10, next page). The long leg of the T has a 1-inch male pipe thread on it. You turn the T handle clockwise into the top of the pitless adapter, and a quick upward jerk will separate the two halves. The pump is now free and can be hoisted up. But you better get some help — this can be a back-breaking job.

Figure 9. The two-piece pitless adapter connects the pipe from the house to the pipe running to the pump. The piece on the left in the top photo is mounted on the well casing below the frost line; the piece on the right is slid onto its mate and allows the pump to be removed, if necessary. The O-ring seals the two pieces together. A little grease prevents damage to the O-ring as the two are joined. The female threads at the top of the assembled pitless adapter (bottom) receive the homemade T bar, which lowers it to its mate mounted to the well casing.

The Installation

On a new job, the first thing I do is to roll out the poly pipe to get rid of its circular memory. I start at the well and roll it out into a large flat circle and then back to the well again. (By making a circle like this, you only have to pull half the pipe length at one time.) Next, I roll out the wire right next to the pipe. I leave several extra feet at the wellhead as slack, then cut it close to the pump.

One end of the pipe gets a pitless adapter fitting that matches the half in the well casing; the other end gets a pump. One 1-inch male insert adapter screws into the pitless, and another screws onto the pump head. This adapter has 1-inch threads on one end and a barbed insert fitting that slips into the poly pipe on the other. A check valve may have to screw into the head of the pump first, depending on the brand of pump you buy. The poly pipe slips over the barbed insert fitting and fastens with two marine clamps. For depths over 300 feet, I use extra long insert fittings, which are long enough to get four clamps on.

With the pump now attached to the pipe, you clamp the torque arrestor on immediately above the pump head. It's cut in half — so you put half on one side of the pipe and half on the other. Squeeze out the middle of the arrestor till it's slightly larger than the casing. The weight of the pump helps to drag the snug-fitting torque arrestor down the well casing.

Next, I splice the cable to the pump. Once that's done, the wire gets taped to the pipe every 5 feet, all the way to the pitless adapter.

Once the pump is on the pipe and is wired together, I'm ready to lower the pipe and pump into the well. The opposite end of the pipe is attached to half of the pitless adapter and has the long T handle in it. I have to make certain as I lower the pump and pipe that no dirt gets into the greased O-ring in the other half of the pitless adapter. Also, the end of the casing is often sharp — don't let the pipe or wire get nicked. There's a plastic fitting that slips over the well casing to make sure that doesn't happen, but I just use a scrap of poly pipe that's split down the side.

The last thing I do as the remainder of the pipe goes into the well is grab the T handle and guide the pitless adapter to its mate attached to the casing. Gravity keeps it from pulling out, and the O-ring makes the seal.

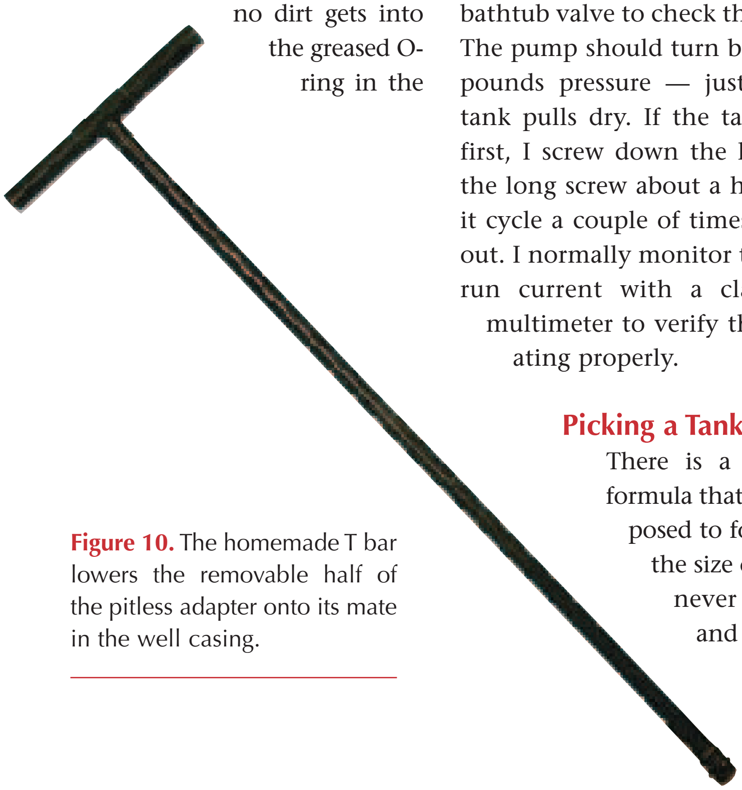


Figure 10. The homemade T bar lowers the removable half of the pitless adapter onto its mate in the well casing.

Hookup

Once the pipes are all installed, I connect 240 volts from the panel. Water should come out — but not immediately. First, I open up the valve on the tank T and let the air out. The water, as it comes up the pipe, will be shoving air ahead of it, and that air must be let out of the system. As soon as I start getting water out of the valve, I close it — water will now start filling the tank. You can hear it as it fills. The bladder expands as water enters the tank. Once the tank is filled and the pump turns off (at 50 pounds on a 30/50 switch), I open the house valve and a bathtub valve to check the operation. The pump should turn back on at 30 pounds pressure — just before the tank pulls dry. If the tank goes dry first, I screw down the little nut on the long screw about a half turn. Let it cycle a couple of times to check it out. I normally monitor the start and run current with a clamp-around multimeter to verify that it's operating properly.

Picking a Tank

There is a complicated formula that you are supposed to follow to pick the size of the tank. I never follow it, and neither does anyone else I know. The formula is based on the need to allow the pump to run at least a couple of minutes once it turns on. My formula for tank sizing is to get the largest tank you can afford — assuming the well is not a low-yield well. There are two reasons for picking a big tank: First, if the electricity goes off, the only water you'll have is what's in the tank. Second, a pump's life is measured in how many times it will turn on. The smaller the tank, the more the pump has to turn on, so the shorter its life span. Be sure to get a quality tank, not a cheap one. I always install the Well-X-Trol brand.

Picking a Pump

I use only Jacuzzi, but, admittedly, it's hard to find a bad submersible pump manufacturer. Most use the same motor, Franklin. I insist on that motor because replacements are easy to get, so the customer doesn't have to be without water for long if it dies. It's a good idea to look at what the pump is made of. If you get plastic, make sure the manufacturer has a good reputation — some don't. Stay away from cast iron — it will rust heavily. Brass and stainless steel are best.

The pumping rate in gallons per minute is another variable to look at when picking the pump. The most common pumps are rated at 7 to 10, simply because most wells have a limited recharge rate. If you get a higher-rated pump, make sure you match it with a larger tank. You can't install a large pump and have it fill the tank in five seconds — it will ruin the pump. For larger-capacity pumps, use larger tanks and install multiple tanks in parallel.

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