V. Know How to Maintain an Efficient Pump

There are at least four important aspects of maintaining an efficient pumping plant:

1. Initial specification and installation of the pumping plant.
2. Ensuring that standard ("janitorial") maintenance procedures necessary to keep machinery running are employed.
3. Knowing if the pump's operating conditions have changed.
4. Knowing if the required operating conditions have changed.

The first and second aspects are not discussed here. It is assumed that an efficient pump was specified and installed correctly initially and the pump owner has received proper maintenance instructions and guidance from his or her pump installer. Further, it is assumed that these maintenance procedures are known and are being followed (i.e. maintaining oil levels in oil cans, correct packing installation and adjustment, periodic inspections of electrical panels).

The Program is most interested in the last two aspects listed above: knowing if the pump's operating condition has changed and knowing whether the required operating conditions have changed. The former is concerned with the physical condition of the pump, especially wear of the impellers or bowls. The latter is concerned with whether the pumping requirements have changed. For example, has there been a change in the irrigation system that requires more or less flow or pressure? If the pump is in a water well, has there been a systemic change in the water table over time? Either of these situations may be identified through the pump efficiency test. This section discusses pump efficiency tests and how you can utilize them to help maintain an efficient plant in the field.

The APEP provides subsidized pump efficiency tests to pump owners through participating pump test companies. A listing of these companies is contained on the web site ***(www.pumpefficiency.org)*** or you can call any of the offices to locate a pump tester near you.

Pump Efficiency Tests

What is a Pump Test?

A pump test measures various aspects of the pump's operation. The end result of a pump test is an estimate of the overall efficiency of your pump and the cost of running it *under the conditions of the test.* The test also may give an indication of water well performance.

Who Does the Pump Testing?

Pump tests may be available from:

- Public utilities - using either their own employees or contract testers.
- Pump dealers - using their own employees or contract testers.
- Independent pump test companies - many of these testers have a public utility background.

What Does a Pump Tester Measure?

The tester measures at least four variables:

1. Water flow rate;
2. Pumping lift (or inlet pressure);
3. Pump discharge pressure; and
4. Energy input to the pumping plant.

Calculations are performed with the flow, lift, and pressure measurements and the results are compared to the energy input. A sample pump test report and an explanation of what it measures and calculates can be found on pages 2.14 - 2.15.

Why Should I Test My Pump?

Regular pump testing can identify problems before a breakdown occurs or before energy bills climb. This allows you to perform an objective economic analysis to identify when it can be profitable to invest in a retrofit or repair. On a new pump, a test will establish a baseline of performance and verify that equipment is operating as designed. A typical analysis of pumping costs derived from a test, along with explanations of the variables used in the calculations, is shown on page 2.16 - 2.17.

How Do I Prepare for a Pump Test?

Check with your pump tester about how to prepare for a pump test. Some testers use flow measurement equipment that requires an access hole in the pump discharge pipe. Generally, the pump needs to be off in order to cut the hole and insert the device. Some measurement devices do not require this provision.

The pump must be running during the test and there must be some place for the pumped water to go. If the pump is in a water well, the tester will need to run the pump for 15-60 minutes to stabilize the pumping water level.

The pump tester also will need information regarding the pump's management and design in order to do a complete cost analysis. Key information will include:

- annual acre-feet pumped (or hours of operation);
- average cost of energy for the year ($/kWh or $/therm);
- intended operating condition;
- required flow rate; and
- required discharge pressure of the pump.

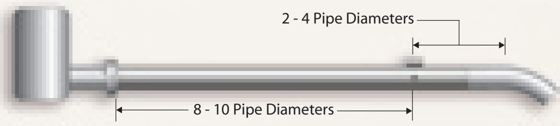
If a water well is running when the tester arrives, the tester will want to shut it off and measure the "recovered water level" of the well. This is valuable information for you that indicates current well performance.

Can Two Pumps Be Tested Together?

Pumping plants may be designed with a well pump to lift the water to the surface and a booster pump to supply pressure to the irrigation system. Typically, the well pump is tested first and then the well/booster combination is tested. The booster pump efficiency is determined by subtracting the inlet pressure into the booster. In some cases, amperage and voltage readings for each pump are taken to determine input horsepower.

What is Needed for Accurate Measurements?

Water flow in a pipe can only be accurately determined if the location for flow measurement (known as the test section) is free from turbulence. Ideally, the test section should be a run of straight pipe with lengths 8 - 10 pipe diameters upstream and 2 - 4 pipe diameters downstream of the measurement point that are free of obstructions or turns (as shown in the diagram to the right). In addition, access via a sounding tube or a factory-made hole in the discharge head may be needed to determine standing and pumping water levels in a well.



This schematic shows an ideal test section:

- 8 - 10 pipe diameters upstream
- 2 - 4 pipe diameters downstream, clear of obstructions or turns

(For a 6" diameter pipe this would mean 48" to 60" upstream and 12" to 24" downstream clear.)

What is a Multi-Condition Pump Test?

A pump can operate with a wide variety of flow and pressure outputs. A multi-condition test consists of making the required measurements at several different flow rates. This type of test is useful in situations where the pump design is unknown or where aquifer or discharge conditions have changed substantially.

How Do I Use the Data from a Pump Test?

You should have a copy of your pump's original pump performance curve. Record the results of each pump test and compare them to that curve and to previous tests. Consult with your pump dealer to determine if a pump adjustment or repair will be profitable.

IMPORTANT!

The pump test results are only valid for the combination (or combinations) of flow and total lift measured. You should attempt to ensure that the test conditions are as close as possible to typical running conditions.

How Often Should I Test My Pump?

A pump should be tested every 1 to 3 years depending on the annual usage and severity of operating conditions. For example, you might want to test a well that is pumping a lot of sand every year. On the other hand, a booster pump supplied by clean water might only be tested once every 2 or 3 years.

How Can I Obtain a Pump Test?

Log on to the Program's web site or call one of the Program offices to obtain a list of participating pump test companies. You can use any of the companies on this list - just call them to arrange the time of the test. They will handle all of the paperwork and the rebate for the pump test will be paid directly to them.

How to Interpret a Pump Test Report

The results section of an electric-powered pump test report prepared by one of the Program's participating pump test companies is shown below.

The following explanations can give you a better idea of what is measured and calculated in a pump test:

Run Number 1 of 1		
1.	Standing Water Level *(ft):*	43
2.	Recovered Water Level *(ft):*	45
3.	Draw Down *(ft):*	5
4.	Pumping Water Level *(ft):*	48
5.	Discharge Pressure at Gauge *(psi):*	20.3
6.	Total Lift *(ft)*:	95
7.	Flow Velocity *(ft/sec)*:	3.8
8.	Measured Flow Rate *(gpm):*	440
9.	Customer Flow Rate *(gpm):*	450
10.	Well Specific Capacity *(gpm/ft)*:	88
11.	Acre-Feet per 24 Hours:	1.9
12.	Cubic Feet per Second *(cfs):*	0.98
13.	Horsepower Input to Motor:	23.1
14.	Percent of Rated Motor Load:	104%
15.	Kilowatt Input to Motor:	17.2
16.	Kilowatt-Hours per Acre-Foot:	212
17.	Cost to Pump an Acre-Foot:	$22.26
18.	Energy Cost *($/Hours):*	$1.81
19.	Base Cost per kWh:	$0.105
20.	Name Plate rpm:	1760
21.	Measured rpm:	1755
22.	**Overall Plant Efficiency *(%):***	**45.7%**

1. ***Standing Water Level*** - The water level in the well when a pump has not been running.
2. ***Recovered Water Level*** - The water level in the well 10 minutes after shutting off the pump.
3. ***Draw Down*** - The difference between the pumping water level *(line 4)* and the standing water level *(line 1)*.
4. ***Pumping Water Level*** - Where the water level in the well stabilizes under constant pumping conditions.
5. ***Discharge Pressure at Gauge*** - The pressure on the outlet side of the pump.
6. ***Total Lift*** - Includes the pumping water level, discharge pressure, and any gauge corrections.
7. ***Flow Velocity*** - How fast the water is moving in the discharge pipe. It should be 1 foot per second or faster to ensure an accurate test.
8. ***Measured Flow Rate (gpm)*** - The flow rate measured in gallons per minute using the tester's instruments.
9. ***Customer Flow Rate (gpm)*** - The flow rate measured with the customer's flow meter *(if one is present)*.
10. ***Well Specific Capacity*** - The measured flow rate divided by the draw down *(line 8 divided by line 3)*. It is a measure of well performance, ***not*** pump performance.*
11. ***Acre-Feet per 24 Hours*** - The number of acre-feet pumped in 24 hours at the measured flow rate. One acre-foot of water is equal to 325,851 gallons of water.
12. ***Cubic Feet per Second (cfs)*** - The measured flow rate expressed as cubic feet of water per second.
13. ***Horsepower Input to Motor*** - The horsepower input to the motor read at the utility meter.
14. ***Percent of Rated Motor Load*** - The estimated horsepower output of the motor divided by the name plate horsepower. If this is not between 80% and 115% it is an indication that the motor is not matched to the pumping condition.
15. ***Kilowatt Input to Motor*** - The power input to the motor in terms of kilowatts. One horsepower is equal to 0.746 kilowatts.
16. ***Kilowatt-hours per Acre-Foot*** - The amount of kilowatt-hours required to pump an acre-foot of water at the operating condition measured.
17. ***Cost to Pump an Acre-Foot*** - Kilowatt-hours per acre-foot multiplied by the Base Cost per kWh *(line 19)*.
18. ***Energy Cost ($/hour)*** - The cost per hour to run the pump at the Base Cost per kWh *(line 19)*.

19. ***Base Cost per kWh*** - The average cost of a kilowatt-hour for this account.

20. ***Name Plate rpm*** - The rated speed of the motor.

21. ***Measured rpm*** - The actual rotational speed measured.

22. ***Overall Plant Efficiency*** - The power output of the pump *(a function of the flow rate and total lift)* divided by the input power.**

* Well-specific capacity is a complex relationship based on the aquifer conditions, well casing diameter, well screen, gravel pack selection, and the initial development. For example, high specific capacity wells in the San Joaquin Valley have specific capacity greater than 100 gpm per foot of draw down. Good wells are between 50 to 100 gpm per foot. Low specific capacity of 5 to 20 gpm per foot may be typical for your area or may indicate a problem. Well performance will generally degrade with time. Well screens can corrode or encrust with various deposits that reduce flow openings into the well. Gravel packs can also experience plugging from fine materials such as silt. Attempting to pump too much water by using too big a pump for the aquifer also results in low well specific capacity. This subject is very important to your pumping costs. Consult with your pump dealer and/or well driller if the pump test history reveals significant reductions in well specific capacity over time.

**Overall plant efficiency can be generally characterized as follows:

- 60% and higher is excellent.
- 50% to 60% is good.
- 49% or less indicates a pump that may need a retrofit, repair, or adjustment. It also may indicate the pump is not matched to the current required operating conditions. An example of this would be where a water table has dropped substantially over time, increasing the total lift above the original specifications.

Pumps with submersible motors will usually run about 10% lower efficiency in each of the categories above. For example 50% or above would be considered excellent for a submersible pump.

IMPORTANT!

*These are **general** characterizations. **Always** consult with your pump service company and other available experts before making the decision to retrofit/repair a pump.*

Pumping Cost Analysis

Below is an example of the pumping cost analysis section of an electric-powered pump test report prepared by a participating pump test company of the Program.

Assumptions	1. Overall plant efficiency is improved to: 66.0%			
	2. Motor loaded at: 105%			
	3. Flow rate will be: 540 gpm			
	4. Total Head will be: 117 feet = 49 ft PWL, 29 psi discharge (PWL = pumping water level)			
	5. Water requirements will be: 122.5 acre-ft/year			
		Existing Efficiency	**Improved Efficiency**	**Estimated Savings**
6.	kWh/AF:	213	182	31
7.	Estimated Total kWh:	25,970	22,242	3,728
8.	Average Cost per kWh:	$0.13	$0.13	
9.	Average Cost per hour:	$3.15	$3.00	$0.15
10.	Average Cost per Acre-Foot:	$28.04	$24.98	$3.06
11.	Estimated Acre-Feet Per Year:	123	123	
12.	Overall Plant Efficiency:	45.7%	66.0%	
13.	**Estimated Total Annual Cost:**	**$3,449**	**$3,073**	**$376**

IMPORTANT!

The pumping cost analysis presented is only valid for the assumptions listed in lines 1 - 5 and for the conditions measured during the test. One or more of the assumed variables resulting from a pump repair could be in error and the economics presented would be misleading. Use this section only as a guide to the magnitude of potential savings. ***Always*** *consult with your pump service company and other available experts before making the decision to retrofit/repair a pump.*

LINES 1 - 5:

Lines 1-5 list the important assumptions regarding the pump performance after any retrofit or repair, including:

1. The improvement expected in Overall Plant Efficiency.
2. Motor loading (this may be greater than 100% if it is currently measured as greater than 100%).
3. Any change in Flow Rate.
4. Any change in Total Lift.
5. Annual water requirements will be assumed to be unchanged.

The software used by participating pump test companies allows for any of these assumptions to be changed as needed. You may want to discuss these assumptions with the tester so that they match your expectations (or the expectations of your pump repair company).

LINES 6 - 13:

Lines 6 - 13 are termed the "Before and After" section and list statistics based on the measured condition and the improved condition assumed as a result of a retrofit/repair project.

6. ***kWh/AF*** - The kilowatt-hours required to pump an acre-foot through the system.
7. ***Estimated Total kWh*** - The total kilowatt-hours used annually if the hours of operation or total acre-feet pumped per year are known.
8. ***Average Cost per kWh*** - The average cost per kilowatt-hour as stated by you, or estimated by the tester based on your pump size and rate schedule.
9. ***Average Cost per Hour*** - The average cost per hour to run the pumping plant.
10. ***Average Cost per Acre-Foot*** - The average cost to pump an acre-foot of water through the system.
11. ***Estimated Acre-Feet per Year*** - The estimated acre-feet of water per year pumped through the system.
12. ***Overall Plant Efficiency*** - The overall pumping plant efficiency *(which may be zero in the case where the pumping water level in a well cannot be measured for some reason).*
13. ***Estimated Total Annual Cost of Energy*** - The estimated annual cost of energy may not include demand charges or other surcharges to run the pump. This will be zero if the annual hours of operation or annual acre-feet pumped are not known.

IMPORTANT!

If the annual hours of operation or acre-feet pumped are not known, use line 10 (the average cost per acre-foot) as an indicator of potential energy and dollar savings.

Summary

The second part of the Program's education message is "Know how to maintain an efficient pump." This goes beyond the obvious correct installation and regular janitorial maintenance aspects. We are most interested in making sure that you know if the required operating conditions have changed or the physical operating condition of the pumping plant has deteriorated. Regular pump efficiency tests can tell you the overall efficiency of your plant as well as indicate if it is a pump condition problem or the required operating condition has changed.