DO-IT-YOURSELF AUDIT
A SIMPLE METHOD TO ESTIMATE THE EFFICIENCY OF YOUR PUMPING PLANT

A test of your pumping plant can tell you whether you can save energy and money by adjusting, rebuilding, or replacing the existing pump or power unit. A pumping evaluation involves measuring several operating characteristics of the pump and electric motor. These include:

• depth to water during pumping,
• pump discharge pressure,
• pump flow rate, and
• rate of electrical energy consumption.

From these measurements, you can calculate both the water horsepower – or rate of useful work done by the pump – and input horsepower equivalent – or rate of energy used by the motor. The overall pumping plant efficiency is the water horsepower, or output, divided by the input horsepower equivalent.

While this method will help you estimate your pump’s efficiency, it doesn’t include the efficiency of the rest of your irrigation system.

Ideally, you should conduct an annual test on your system to track changes in performance and identify potential problems before they become serious enough to shut down the system.

To conduct this test, you’ll need:

✓ A good quality pressure gauge (preferably oil-filled) mounted on the pipe on the discharge side of the pump.
✓ A 5-gallon bucket with a length of garden hose that will fit over sprinkler heads, OR a working flow meter mounted at least 5 pipe diameters downstream of the pump or other bends, valves or changes in pipe. With a permanent marker, mark the 5-gallon line on the inside of the bucket.
✓ A stopwatch and a calculator.

When the system is operating under normal, stable conditions, take the following readings and complete these calculations:

1. **FIND TOTAL DYNAMIC HEAD (tdh)**

   Read pressure from gauge ______ psi × 2.31 = _____ Feet

   Height in feet IF pump is ABOVE water surface\(^\dagger\) + _____ Feet

   OR

   Height in feet IF pump is BELOW water surface\(^\dagger\) - _____ Feet

\(^\dagger\) Height is the distance from the surface of the water source (e.g. well, ditch, pond, or stream) to the center line of the pipe on the discharge side of the pump.

From the measured pressure, add or subtract height above or below water surface to get an estimate of Total Dynamic Head ______tdh (feet)
2A. FIND THE FLOW RATE IN GALLONS PER MINUTE (GPM)-
HAND LINE OR WHEEL LINE INSTRUCTIONS

If your system has a flow meter installed, read the gpm on the gauge. If the meter reads in cfs (cubic feet per second), convert that figure to gpm by multiplying cfs $\times$ 448.8 ______ gpm

If you don’t have a flow meter and are using a wheel line or hand line, you can instead measure the flow of one sprinkler per lateral that is situated on relatively level ground with uniform nozzle sizing. The selected sprinkler should be 1/3 down the length of the lateral from the mainline to estimate the average flow of each lateral. Choose one operating sprinkler on each lateral. If your ground slopes more than about 2%, or if different sized nozzles are used, this test should include additional heads spaced along the lateral. Choose the first, last and others at equal distances apart.

To measure the flow, hold one end of a garden hose over a sprinkler head and put the other end in the five-gallon bucket.

Use your stopwatch to estimate the time in seconds to fill the bucket. For greater accuracy, take more than one reading per sprinkler and average the times.

Repeat for the other sprinklers.

<table>
<thead>
<tr>
<th>Lateral 1</th>
<th>Lateral 2</th>
<th>Lateral 3</th>
<th>Lateral 4</th>
<th>Lateral 5</th>
<th>Lateral 6</th>
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<tbody>
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</tbody>
</table>

Add up the total seconds.

TOTALS:  
_____ sec  ____ sec  _____ sec  _____ sec  _____ sec  _____ sec

Calculate average seconds per lateral; average seconds = total seconds divided by the number of sprinkler heads tested per lateral.

AVERAGES:  
_____ sec  ____ sec  _____ sec  _____ sec  _____ sec  _____ sec

Figure the average flow per sprinkler. Divide the number 300 (a conversion factor) by the average seconds to get gpm per sprinkler:

**AVERAGE FLOW PER SPRINKLER:**  
_____ gpm  ____ gpm  _____ gpm  _____ gpm  _____ gpm  _____ gpm  

Find the flow per lateral. Multiply average flow per sprinkler times the total number of heads on lateral.
FLOW PER LATERAL:

____ gpm  ____ gpm  ____ gpm  ____ gpm  ____ gpm  ____ gpm

Find the total system flow. Add up all of the lateral flows.

TOTAL FLOW = ________gpm

2B. FIND THE FLOW RATE IN GALLONS PER MINUTE (GPM) - PIVOT INSTRUCTIONS

If your system has a flow meter installed, read the gpm on the gauge. If the meter reads in cfs convert that figure to gpm by multiplying cfs × 448.8

If you don’t have a flow meter and are using a pivot, you can instead measure the flow of one sprinkler in each set of nozzle diameters along the length of the pivot. Pivot nozzle sizing can often be determined by consulting the documentation provided when the pivot was installed or re-nozzled. To measure the flow, hold one end of a hose over a sprinkler head and put the other end in the five-gallon bucket.

Use your stopwatch to estimate the time in seconds to fill the bucket.

Repeat for each set of nozzle diameters.

<table>
<thead>
<tr>
<th>Number of seconds to fill bucket</th>
<th>Average gpm (300 divided by. number of seconds)</th>
<th>Number of sprinklers in each set</th>
<th>Total gpm in each set (ave. gpm × number of sprinklers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>____ sec</td>
<td>____ gpm</td>
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<td>____ gpm</td>
<td>____</td>
<td>____ gpm</td>
</tr>
</tbody>
</table>

Find the total sprinkler flow. Add up all of the flows from each set.

Estimate end gun flow using the table on the following page.

Add end gun flow to total sprinkler flow to find total system flow.

TOTAL FLOW for pivot = ________ gpm
3. **MEASURE ENERGY USE**

If you are conducting this test on a system with a pivot, turn off the pivot drive and end gun booster pump if possible while measuring the energy use. You want to measure just the electricity that the pump motor is using to pump the water.

Locate the **meter constant** on electric meter. It will be marked Kh and will be a number such as 57.6 or 43.2.

Using a stopwatch, time the number of seconds it takes for the disk in the meter to make ten revolutions (or for the little bar to move across the screen 10 times). Note: Some meters have “blinking boxes” or other means of indicating energy use. Your electric utility may be able to provide a method for your specific meter.

Use this formula to find input power in kilowatts (kW):

\[
kW = \frac{3.6 \times \text{Revolutions} \times \text{Kh}}{\text{Seconds}}
\]

Convert to input horsepower by multiplying kW by 1.34.

\[
______ \text{kW} \times 1.34 = \underline{______} \text{hpi}
\]

4. **FIND WATER HORSEPOWER (whp)**

Multiply the total flow (from Step 2) by the total dynamic head (from Step 1) and divide by 3,960 (a conversion factor):

\[
\text{whp} = \frac{\text{Total gpm} \times \text{tdh (FEET)}}{3,960} = \frac{(\text{gpm}) \times (\text{tdh})}{3960} = \underline{______}
\]

5. **DETERMINE YOUR PUMPING PLANT PERFORMANCE**

The pumping plant is the pump and motor considered together. Divide water horsepower (from Step 4) by the input horsepower (from Step 3):

\[
\text{Performance} = \frac{\text{whp}}{\text{hpi}} = \underline{______} \% \text{ Efficiency}
\]

6. **SELECT PUMP EFFICIENCY**

From the table below, select the expected efficiency of your pumping plant for its rated horsepower:

<table>
<thead>
<tr>
<th>Efficiency Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rated Motor Size (Hp)</strong></td>
</tr>
<tr>
<td>3 to 5</td>
</tr>
<tr>
<td>7.5 to 10</td>
</tr>
<tr>
<td>15 to 30</td>
</tr>
<tr>
<td>40 to 60</td>
</tr>
<tr>
<td>75 +</td>
</tr>
</tbody>
</table>

Note: These efficiencies are for older pumps in excellent condition. New pumps should have higher efficiencies.

If your pumping plant efficiency is substantially less than the expected efficiency listed in the table, there is potential for improvement.
**EXAMPLE FOR 30 HP CENTRIFUGAL PUMP WITH TWO WHEEL LINES AND ONE PIVOT**

Based on some hypothetical calculations, this is how you would estimate the pump’s efficiency:

1. **FIND TOTAL DYNAMIC HEAD (tdh)**
   
   Pressure from gauge = 45 PSI × 2.31 = 104 Feet
   
   Height in Feet to center of pump from water surface = + 10 Feet
   
   **114** tdh

2A. **FIND THE FLOW RATE (gpm) - WHEEL LINE**

   The two wheel lines each have 35 sprinkler heads. The system has no flow meter so you would use a 5-gallon bucket to find the flow.

   Measure the flow of one sprinkler per lateral (assumed to be situated on relatively level ground). Use your stopwatch to estimate the time in seconds to fill the bucket. For greater accuracy, take more than one reading per sprinkler and average the times.

   Repeat for the other sprinklers.

   Lateral 1       Lateral 2

   Sprinkler 1 – 1/3 way down lateral, 1st reading 73 sec 69 sec
   Sprinkler 1 – 1/3 way down lateral, 2nd reading 72 sec 71 sec

   Add up the total seconds. 145 sec 140 sec

   Calculate average seconds per lateral. Average seconds = total seconds divided by the number of sprinkler heads tested per lateral.

   **72.5 sec 70 sec**

   Figure the average flow per sprinkler. Divide the number 300 (a conversion factor) by the average seconds to get gpm per sprinkler:

   **4.1 gpm 4.3 gpm**

   Find the flow per lateral. Multiply average flow per sprinkler times the total number of heads on lateral.

   **35 × 4.1 = 144 gpm 35 × 4.3 = 151 gpm**

   Find the total wheel line flow by adding up all of the lateral flows.

   **TOTAL FLOW = 295 gpm**

2B. **FIND THE FLOW RATE (gpm) - PIVOT**

   The pivot has 8 sets of nozzle diameters with 12 nozzles per set.

   Measure the flow of one sprinkler in each of the sets of nozzle diameters along the length of the pivot.

   Use your stopwatch to estimate the time in seconds to fill the bucket.

   Repeat for each set of nozzle diameters.
### No. seconds to fill bucket (300 divided by No. seconds) × No. sprinklers
<table>
<thead>
<tr>
<th>No. seconds</th>
<th>Average gpm</th>
<th>No. sprinklers</th>
<th>Total gpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>98</td>
<td>3.1 gpm</td>
<td>12</td>
<td>36.7 gpm</td>
</tr>
<tr>
<td>92</td>
<td>3.3 gpm</td>
<td>12</td>
<td>39.1 gpm</td>
</tr>
<tr>
<td>86</td>
<td>3.5 gpm</td>
<td>12</td>
<td>41.9 gpm</td>
</tr>
<tr>
<td>82</td>
<td>3.7 gpm</td>
<td>12</td>
<td>43.9 gpm</td>
</tr>
<tr>
<td>76</td>
<td>3.9 gpm</td>
<td>12</td>
<td>47.4 gpm</td>
</tr>
<tr>
<td>70</td>
<td>4.3 gpm</td>
<td>12</td>
<td>51.4 gpm</td>
</tr>
<tr>
<td>66</td>
<td>4.5 gpm</td>
<td>12</td>
<td>54.5 gpm</td>
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<td>12</td>
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Find the total sprinkler flow. Add up all of the flows from each set.

The end gun operates at 60 psi and has a nozzle diameter of ½ inch. From the table, the estimated end gun flow is 57.8 gpm.

**TOTAL FLOW** for pivot = **433 gpm**  
**TOTAL SYSTEM FLOW** (for wheel lines and pivot combined) = **728 gpm**

### 3. MEASURE ENERGY USE

The meter constant (Kh) is 21.6

Meter disk required 31 seconds to make 10 revolutions.

For this system, the pivot drive and end gun booster pump were both off while the energy use was measured.

Input power in kilowatts (kW) = \(3.6 \times 10 \times 21.6 = 25.1\) kW

Convert to horsepower by multiplying kW by 1.34. \(25.1 \times 1.34 = 33.6\) hpi

### 4. FIND WATER HORSEPOWER (whp)

Multiply the total flow by the total dynamic head and divide by 3,960 (a conversion factor):

\[\text{whp} = \frac{\text{Total gpm} \times \text{tdh (feet)}}{3,960} = \frac{728 \times 114}{3,960} = 21\] whp

### 5. DETERMINE YOUR PUMPING PLANT PERFORMANCE

Performance = \(\frac{\text{whp}}{\text{hpi}} = \frac{21}{33.6} = 62.4\%\) Efficiency

### 6. SELECT PUMP EFFICIENCY

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The efficiency of the 30 horsepower pumping plant in this example is 62.4%, which is less than the 69% expected efficiency. The pump and motor could likely benefit from being rebuilt.