How Long Does Applying 1 Inch of Water Take With a Center Pivot?

Knowing how long applying a certain amount of water takes with a center pivot is a very important part of irrigation management.

When dealers install a new center pivot or re-nozzle an existing pivot, they provide a chart showing the application amount for various settings of the percent timer. The percent timer determines the speed of the pivot and, thus, for a given flow rate, the amount of water applied.

Sometimes the chart for a particular center pivot is misplaced or lost. Often the flow rate to the pivot will change from what it was when the original chart was made. Through time, the flow rate will decrease, which increases the time to apply the desired amount.

If you know the following four parameters, you can calculate an application-time chart for any center pivot:

1) Area of coverage (this includes the effective area watered with an endgun)
2) Desired depth of application (water into the soil)
3) Flow rate to the pivot
4) Sprinkler application efficiency

Use this equation to calculate the application time:

\[
\text{Application Time} = \frac{453 \times \text{Area} \times \text{Depth}}{\text{Flow Rate} \times \text{Application Efficiency}}
\]

Table 1. Time in hours to apply various depths of water with a 128-acre pivot, assuming an application efficiency of 0.85. For example, at a flow rate of 800 gallons per minute, applying 1 inch of water takes a little more than 85 hours.

<table>
<thead>
<tr>
<th>Application Depth (inches)</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>51.2</td>
<td>40.9</td>
<td>34.1</td>
<td>29.2</td>
<td>25.6</td>
<td>22.7</td>
</tr>
<tr>
<td>0.4</td>
<td>68.2</td>
<td>54.6</td>
<td>45.5</td>
<td>39.0</td>
<td>34.1</td>
<td>30.3</td>
</tr>
<tr>
<td>0.5</td>
<td>85.3</td>
<td>68.2</td>
<td>56.8</td>
<td>48.7</td>
<td>42.6</td>
<td>37.9</td>
</tr>
<tr>
<td>0.6</td>
<td>102.3</td>
<td>81.9</td>
<td>68.2</td>
<td>58.5</td>
<td>51.2</td>
<td>45.5</td>
</tr>
<tr>
<td>0.7</td>
<td>119.4</td>
<td>95.5</td>
<td>79.6</td>
<td>68.2</td>
<td>59.7</td>
<td>53.1</td>
</tr>
<tr>
<td>0.8</td>
<td>136.4</td>
<td>109.1</td>
<td>91.0</td>
<td>78.0</td>
<td>68.2</td>
<td>60.6</td>
</tr>
<tr>
<td>0.9</td>
<td>153.5</td>
<td>122.8</td>
<td>102.3</td>
<td>87.7</td>
<td>76.7</td>
<td>68.2</td>
</tr>
<tr>
<td>1.0</td>
<td>170.5</td>
<td>136.4</td>
<td>113.7</td>
<td>97.5</td>
<td>85.3</td>
<td>75.8</td>
</tr>
<tr>
<td>1.1</td>
<td>187.6</td>
<td>150.1</td>
<td>125.1</td>
<td>107.2</td>
<td>93.8</td>
<td>83.4</td>
</tr>
<tr>
<td>1.2</td>
<td>204.6</td>
<td>163.7</td>
<td>136.4</td>
<td>116.9</td>
<td>102.3</td>
<td>91.0</td>
</tr>
</tbody>
</table>

Where the application time is in hours, area is the acres covered, depth is the desired application depth in inches, the flow rate is in gallons per minute and the application efficiency is a decimal value between 0 and 1. An example of calculating an application amount chart for a 128-acre center pivot is shown in Table 1.

The application efficiency is the ratio of the volume of water that gets into the soil to the volume of water that is pumped. Weather conditions during the day can affect this value significantly.

In the morning, when no wind is blowing, the application efficiency might be more than 0.9 for a pivot. By midafternoon, when the air temperature is high, the relative humidity is low and the wind is greater than 15 mile per hour, the application efficiency might drop to below 0.5. Research has shown that an application efficiency of 0.85 is a good average value to use for North Dakota conditions.

The values in Table 1 will be correct if mechanical aspects of the sprinkler system are not creating problems. However, plugged nozzles, nozzle wear, sprinklers not rotating properly, pump wear that causes a reduction in pressure or flow rate or both, and leaks in the piping are some of the more common mechanical problems associated with sprinkler systems.
The only way to truly find out the application amount under a pivot is to measure it. A can-test using four or five identical rain gauges, each under a different span of the center pivot, will provide an estimate of the average application amount.

For a typical seven- or eight-tower pivot, the first rain gauge should be located somewhere between the second and third tower, with the rest located between the remaining towers. To continually monitor the application amounts of the pivot, the rain gauges could be left in place throughout the growing season.

**Tom Scherer, (701) 231-7239**  
NDSU Extension Agricultural Engineer  
Thomas.Scherer@ndsu.edu

**Consider Pros, Cons of Alternative Grain Storage Methods**

Grain can be stored in many types of facilities. But all storage options should keep the grain dry and provide adequate aeration to control grain temperature.

Grain must be dry and cool (near the average outdoor temperature) when placed in alternative storage facilities because providing adequate, uniform airflow to dry grain or cool grain coming from a dryer is not feasible.

**Structural Issues**

Grain pushing against the walls can damage buildings not built for grain storage. To estimate the amount of force that grain exerts on a wall, multiply the grain depth at the wall by the grain’s equivalent fluid density (EFD). For example, the force pushing against the base of a 6-foot wall of a structure containing grain would be about 204 pounds per linear foot of the wall (6 feet x 34 pounds per cubic foot).

The wall must be anchored securely, and its structural members must be strong enough to transfer the force to the building poles or support structure without breaking or excessive bending. The total force per linear foot on the wall is the force at the base multiplied by 1.31 times the wall grain depth divided by two.

For this example, the total force is 802 pounds per linear foot (204 x 1.31 x 6 ÷ 2). In a pole building with poles spaced 8 feet apart, the force against each pole is 6,416 pounds (802 x 8). Typically, you’ll need additional poles and a grain wall to support the grain force in a pole building. Hire an engineer to complete a structural design or analysis or contact the building company for guidance to prevent a structural failure.

Before placing grain in a building previously used for grain storage, look for anything out of alignment, such as the wall bowing. Also check the roofline. Bowing or bending indicates the load on the building exceeds or has exceeded the load for which it was designed and built. Examine connections for separation or movement. A connector failure can lead to a building failure. You may need to reinforce the connection by adding a gusset or splice.

**Storing in Bags**

Storing grain in poly bags is a good option, but it does not prevent mold growth in damp grain or insect infestations. Grain should be placed in the bag at recommended storage moisture contents based on grain and outdoor temperatures. Heating will occur if the grain exceeds a safe storage moisture content and it cannot be aerated in a bag to control heating. The average temperature of dry grain will follow the average outdoor temperature.

Select an elevated, well-drained site for the storage bags, and run the bags north and south so solar heating is similar on both sides. Sunshine on just one side heats that side, which can lead to moisture accumulation in the grain on the cool side. Wildlife can puncture the bags, creating an entrance for moisture and releasing the grain smell, which attracts more wildlife. Quickly seal any punctures. Monitor the grain temperature at several places in the bags.

Never enter a grain bag because it is a suffocation hazard. If unloading the bag with a pneumatic grain conveyor, the suction can “shrink wrap” a person so he or she cannot move and will limit space for breathing.

**Grain Piles**

Grain frequently is stored short term in outdoor piles. However, precipitation is a severe problem for uncovered grain. A 1-inch rain will increase the moisture content of a 1-foot layer of corn by 9 percentage points. This typically leads to the loss of at least a couple of feet of grain on the pile surface, which is a huge loss.

For example, a cone-shaped pile 25 feet high is approximately 59,000 bushels of grain. Losing just 1 foot of grain on the surface is a loss of about 13 percent of the grain, which is worth $39,000 if the grain value is $4 per bushel.

Use a cover to prevent water infiltration. Aeration and wind blowing on the pile generally will not dry wet grain adequately to prevent spoilage.

Drainage is critically important to the success of any grain storage. About 25,000 gallons of water will run off an area about 100 by 400 feet during a 1-inch rain. This water must flow away from the grain and the area next to it. Examine the entire area to assure that flooding will not occur during major rain events.
The storage floor should be higher than the surrounding ground to minimize moisture transfer from the soil into the grain. The outdoor ground surface where grain will be piled should be prepared with lime, fly ash, cement or asphalt to prevent soil moisture from reaching the grain. Make sure the ground surface is crowned so moisture that does get into the pile drains out, rather than creating a wet pocket that leads to grain deterioration.

Look for anything out of alignment in a bunker or bulkhead wall. Any twisting, flexing or bending of a structural member may lead to a failure. Also examine connections for any separation or movement, and reinforce them if necessary. Look for any material deterioration as well, and repair rotted, rusted or corroded members.

Grain Covers
A combination of restraining straps and suction from the aeration system holds grain covers in place. However, you must provide adequate air flow through the grain to control grain temperature. Place perforated ducts on the grain surface under the cover to provide a controlled air intake for the aeration system and provide airflow near the cover to minimize condensation problems under the cover.

Properly sized and spaced ducts should be placed on the ground under the pile to pull air through the grain. If you use a perforated wall, the aeration ducts near the wall should not be perforated or the airflow through the grain will be concentrated near the wall.

Wind velocity will determine the amount of suction you need to hold the cover in place. Some control systems measure wind velocity and start fans based on the wind speed. Backup power may be used to assure that the cover is held down during power outages. Check the backup power to make sure it starts when needed.

Cooling Stored Grain
Cool grain with aeration to reduce the insect infestation potential. Insect reproduction is reduced at temperatures below about 60 F, insects are dormant below about 50 F, and insects can be killed by extended exposure to temperatures below about 30 F.

Cooling grain as outdoor temperatures cool also will reduce moisture migration and the condensation potential near the top of the grain pile. Grain moisture content and temperature affect the rate of mold growth and grain deterioration.

The allowable storage time approximately doubles with each 10-degree reduction in grain temperature. For example, the allowable storage time for 17 percent moisture corn is about 130 days at 50 F and about 280 days at 40 F. The grain should be cooled whenever the average outdoor temperature is 10 to 15 degrees cooler than the grain. It should be cooled to near or below 30 degrees for winter storage, depending on available air temperature.

Aeration ducts need to have perforations sized and spaced correctly for air to enter and exit the ducts uniformly and obtain the desired airflow through the grain. The maximum spacing for aeration ducts is equal to the grain depth to achieve acceptable airflow uniformity.

For more information, do an online search for NDSU grain drying and storage.

Ken Hellevang, (701) 231-7243
NDSU Extension Agricultural Engineer
Kenneth.Hellevang@ndsu.edu

Point Your Center Pivot in the Right Direction
In wind and sleet, the center pivot is a rather fragile machine. From October to April, the worst storms and highest winds generally come from the northwest or southeast. Ice storms and blizzards have damaged many center pivots that were parked pointing in the wrong direction (figure below). Properly parking a pivot will present the smallest surface area to the wind.

Exceptions are center pivots that border windbreaks. In this case, the pivot should be parked next to the windbreak. On hilly fields where the pivot point is at or near the top of the hill, the center pivot should be parked going down the steepest hill.

Tom Scherer, (701) 231-7239
NDSU Extension Agricultural Engineer
Thomas.Scherer@ndsu.edu
For more information on this and other topics, see www.ag.ndsu.edu

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Upcoming Irrigation Workshop

Dec. 10, 2015 (Thursday) – Bismarck Ramkota Hotel

This workshop is held in conjunction with the North Dakota Water User Association’s annual convention on Dec. 9, 10 and 11. The NDSU Extension Service, North Dakota Irrigation Association and North Dakota Water Users Association sponsor the workshop. The convention will include an irrigation and water products exposition.

Water Tour: Buffalo City (Jamestown)

Opportunities and Water Use – Oct. 7

The Jamestown area has many critical water needs. This tour will visit sites that require a good supply of high-quality water, from rural water to agriculture to industry. The tour begins and ends in Jamestown.

Registration is $20 per person and includes tour transportation, meals, refreshments, informational materials and a one-year subscription to North Dakota Water magazine.

To register for this tour, go to www.ndwater.com/programs and click on “Summer Water Tours” on the lefthand menu or send a check to NDWEF, PO Box 2254, Bismarck, ND 58502. Please include the number of people who will be attending. For more information, give us a call or send an email.

North Dakota Water Education Foundation, (701) 223-8332
Fax (701) 223-4645
ndwaterusers@btinet.net