K-STATE
Research and Extension

Interpreting and Using Center Pivot Sprinkler Designs

Agriculture and Natural Resources | **MF3608** | **Irrigation**

Center pivot irrigation systems represent considerable financial investments for crop producers. Personalized pivot engineering design contains information that is important to the maintenance of the system.

Small changes and wear and tear over time can result in subpar performance and excessive water application costs. A common problem is low operation pressure, which results in uneven application depths, especially in fields with significant elevation gradients. Consulting and using pivot design information can improve the functioning of the irrigation system.

The most important document page for pivot operations is often near the back of the documentation and is called the Precipitation Chart for Full Circle (Figure 1). It is often copied, printed, and laminated, and then kept in the pivot control box.

Key items from this page include:

1. Pressure at top of pivot riser (psi). Pressure readings taken at other locations, such as at ground level, will not be accurate. Low pressure is a common problem and results in uneven application.
2. Total gallons per minute (gpm). This is the water volume the system is designed to deliver. It is dependent on the entire irrigation system functioning correctly.

Precipitation (inches)
Time to complete one full rotation around the field (hours)
Design tire size
Total irrigation pipe length (feet)
Total gallons per minute
Percent of the time the pivot is moving

PRECIPITATION CHART FOR FULL CIRCLE

WISH-XXXXX NOVEMBER 25, 2020

DEALER - IRRIGATION DEALER IRRIGATOR - GROWER

TOTAL LENGTH PIPE = 1281.47
GPM UNDER PIPE = 650.56
ACRES UNDER PIPE = 118.43
RANGE OF ENDGUN = .00
GPM OF ENDGUN = .00
ACRES UNDER ENDGUN = .00

SYSTEM PRESSURE = 30 PSI
TOTAL GPM = 650.56

MOTOR SIZE (HP) = 3/4
LOADED MOTOR RPM = 1750
CENTER GEAR BOX RATIO = 40
WHEEL GEAR BOX RATIO = 50
TIRE SIZE = 11 X 24.5
LAST TOWER SPEED (FPM) = 9.70

PRECIPITATION BASED			% TIMER BASED		
PRECIPITATION INCHES	% TIMER SETTING	TIME HOURS	% TIMER SETTING	PRECIPITATION INCHES	TIME HOURS
.16	100.00	13.35 - 801(min)	100.00	.16	13.35 - 801(min)
.20	81.02	16.48	90.00	.18	14.83
.25	64.81	20.60	80.00	.20	16.69
.30	54.01	24.72	70.00	.23	19.07
.40	40.51	32.96	60.00	.27	22.25
.50	32.41	41.20	50.00	.32	26.70
.60	27.01	49.43	45.00	.36	29.67
.70	23.15	57.67	40.00	.41	33.38
.75	21.60	61.79	35.00	.46	38.14
.80	20.25	65.91	30.00	.54	44.50
.90	18.00	74.15	25.00	.65	53.40
1.00	16.20	82.39	20.00	.81	66.75
1.25	12.96	102.99	15.00	1.08	89.00
1.50	10.80	123.59	10.00	1.62	133.50
1.75	9.26	144.18	5.00	3.24	267.00

CAUTION: The relationship between precipitation rate, timer setting, and hours per revolution provided above are theoretical numbers based on the data list at the top of the page. Actual precipitation rates may vary due to the following field and machine conditions: wind drift; evaporation; tire slippage, tire loaded radius; drive train efficiency; elevation changes; soil type. Due to these varying field and machine conditions the above chart should be used as a guide only.

Figure 1. *Precipitation Chart.*

3. Precipitation in inches. This is the depth of water being applied when the pressure is at the design gallons per minute.
4. Time hours. Because the tower furthest from the center of the pivot circumscribes the largest circle and thus most distance, its speed determines how fast the entire pivot can complete a rotation. In the example, if the last tower is moving 100% of the time (% Timer Setting Column), it will take 13.35 hours (801 minutes) for the pivot to make a complete circle. This is the minimum amount of time for the pivot to make a complete watering cycle around the field. Time hours can also be calculated for pivots that make a partial circle if the entire 360 degrees is not being irrigated.
5. Total length of pipe. Represents the radius of the pivot arc, determining how many acres are being watered.

These five key pieces of information are needed to configure real-time monitoring software (AgSense, FieldNet, FieldWise-type monitoring) to fit this system. By entering these numbers, the software provides relevant information for improving irrigation management.

This page also states the design tire size. Tire sizes are sometimes changed to decrease rutting and avoid getting stuck. Tires with a different diameter change the speed the pivot moves and require recalibration of the irrigation system for it to continue to perform as specified.

The title page (Figure 2) provides a description of the sprinkler package purchased. At the upper right-hand corner of the page is the unique design number for this pivot. This number is the equivalent of a serial number. Many of these numbers start with WISH, which stands for Western Irrigation Supply House, a company responsible for many pivot irrigation engineering designs.

Across the top of the page is the dealer who sold the pivot. In the left-hand column is the purchase date, purchaser, and a field identifier for where the pivot was initially located. If the pivot is moved from this location to another, it may need recalibration if the well capacity and pumping plant do not match the original sprinkler package's gpm and psi requirements.

Design information is summarized in the right-hand column. The pivot brand and model are followed by the number of towers and pivot length, which determines how much area is being watered. The operational design pressure and flow rate are important information in this section. Deviations from the design pressure result in the pivot failing to perform correctly. This cannot be overemphasized. Many pivot modifications can result in changes to the pressure, including changes in booms, flow rate, orifices, and end guns, as well as inadequate water or pump functioning. The irrigation system should be periodically tested to make sure the design pressure is maintained to the sprinkler and its associated pressure regulator located furthest from the pivot point.

Sprinkler type and model are shown, followed by the design regulator pressure (10 psi in this example). The inclusion of an end gun is noted next. If an end gun is not specified and added later, it will alter many aspects of pivot system function. Adding a booster pump increases the flow rate of the end gun but may decrease the pressure and/or flow rate in the rest of the system. Often, the application rate under the main pivot system and the end gun will be different, resulting in areas of under- and over-watering. The entire irrigation system will need to be recalibrated or redesigned due to the complex relationship between the well, pump, and pivot.

Finally, the range of elevation in the field is given. In this example, the height of the field can vary by 20 feet (10 feet up or down) from the elevation of the concrete pad on which the pivot point tower sits. The variation in field elevation is not generally measured on

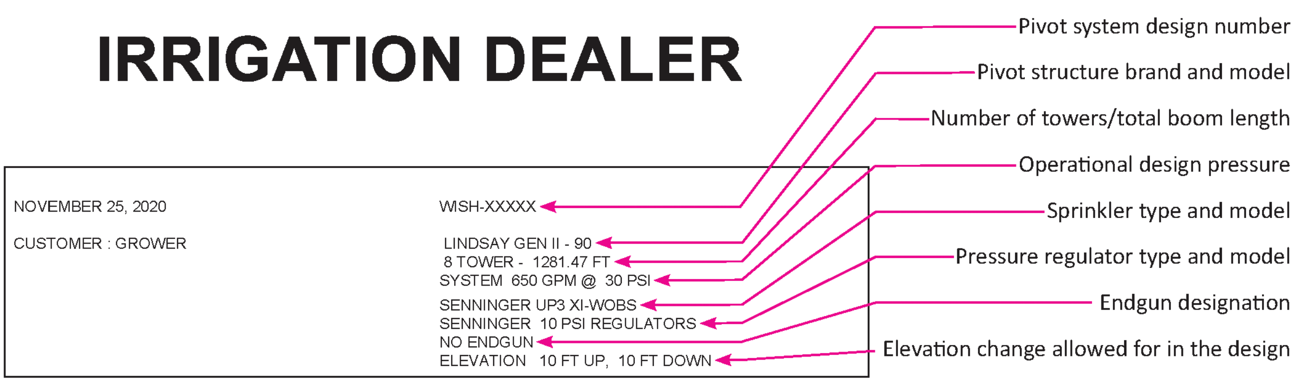

Figure 2. *Title Page.*

TOTAL TARGET GPM	650.00	FRICTION FACTOR USED	138	SPANS	LENGTH	PIPE I.D.
TOP OF PIVOT PRESSURE	30.00	TOTAL LENGTH	1281.47	1	159.60	6.395
NO ENDGUN		NUMBER OF TOWERS	8	6	157.00	6.395
NUMBER OF OUTLETS	180	NUMBER OF SPRINKLERS	167	1	135.00	6.395
				OH	44.87	5.369

SENNINGER UP3 XI-WOBS - 610 BLUE PADS FIRST 47 POSITIONS
SENNINGER UP3 XI-WOBS - 615 BLACK PADS BALANCE
SENNINGER PSR-2 10 PSI SERIES REGULATORS
POLYDROPS® AVERAGE 6 FT
ELEVATION IS 10 FT UP AND 10 FT DOWN

Design regulator pressure
Design friction factor
Spray pad number and type
Individual span lengths
Water distribution height

Figure 3. *Design Summary.*

Outlets wtih plugs
Distance from riser to first outlet
Orifice size

PAGE 4

OUTLET NO.	LAST OUTLET	DISTANCE TO PIVOT	GPM NEED	GPM DEL.	PIPE PSI	NOZZLE PSI	SPRINKLER LABEL AND NOZZLE SIZE	SPRINKLER PAD	SPRK NO.	REG SIZE	PLUG NO.	DROP LENGTH
1		2.92	- - -	- - -	- - -	- - -	- - -	- - -	- - -		1	
2		7.76	- - -	- - -	- - -	- - -	- - -	- - -	- - -		2	
3		15.26	- - -	- - -	- - -	- - -	- - -	- - -	- - -		3	
4		22.59	- - -	- - -	- - -	- - -	- - -	- - -	- - -		4	
5		29.93	- - -	- - -	- - -	- - -	- - -	- - -	- - -		5	
6		37.26	- - -	- - -	- - -	- - -	- - -	- - -	- - -		6	
7	44.76	44.76	0.26	1.16	28.85	11.40	XI-WOB UP3 7 LIME	610 Blue	1	SPSR2-10		78
8	7.00	51.76	0.30	1.16	28.69	11.40	XI-WOB UP3 7 LIME	610 Blue	2	SPSR2-10		78
9	7.50	59.26	0.35	1.16	28.55	11.40	XI-WOB UP3 7 LIME	610 Blue	3	SPSR2-10		84
10	7.33	66.59	0.38	1.16	28.43	11.40	XI-WOB UP3 7 LIME	610 Blue	4	SPSR2-10		84
11	7.17	73.76	0.42	1.16	28.34	11.40	XI-WOB UP3 7 LIME	610 Blue	5	SPSR2-10		84
12	7.50	81.26	0.47	1.16	28.26	11.40	XI-WOB UP3 7 LIME	610 Blue	6	SPSR2-10		84
13	7.33	88.59	0.51	1.16	28.20	11.40	XI-WOB UP3 7 LIME	610 Blue	7	SPSR2-10		84
14	7.34	95.93	0.55	1.16	28.17	11.40	XI-WOB UP3 7 LIME	610 Blue	8	SPSR2-10		84
15	7.33	103.26	0.60	1.16	28.16	11.40	XI-WOB UP3 7 LIME	610 Blue	9	SPSR2-10		84
16	7.50	110.76	0.63	1.16	28.17	11.40	XI-WOB UP3 7 LIME	610 Blue	10	SPSR2-10		78
17	7.00	117.76	0.67	1.16	28.19	11.40	XI-WOB UP3 7 LIME	610 Blue	11	SPSR2-10		78
18	7.50	125.26	0.72	1.16	28.25	11.40	XI-WOB UP3 7 LIME	610 Blue	12	SPSR2-10		72
19	7.33	132.59	0.76	1.16	28.32	11.40	XI-WOB UP3 7 LIME	610 Blue	13	SPSR2-10		72
20	7.34	139.93	0.80	1.16	28.41	11.40	XI-WOB UP3 7 LIME	610 Blue	14	SPSR2-10		66
21	7.33	147.26	0.85	1.16	28.53	11.40	XI-WOB UP3 7 LIME	610 Blue	15	SPSR2-10		60
22	7.50	154.76	1.06	1.16	28.56	11.40	XI-WOB UP3 7 LIME	610 Blue	16	SPSR2-10		54
TOWER 1	159.60	159.60										

Figure 4. *Detailed Description.*

site but provided by the sales company to the engineering firm or determined from mapping software.

The second page of documentation is often standardized design qualifications and not unique to the pivot.

The Design Summary (Figure 3) goes into slightly more detail about the system. Besides the repetition of information from the first page, there is information about the individual length of spans and overall height.

The design friction factor indicates the smoothness of the inside pivot main pipe, usually 6⅝-inch galvanized steel, which can change over time due to corrosion. In locations where the groundwater is known to be corrosive, the friction factor should be periodically checked as increased friction may indicate that alterations are needed elsewhere in the pivot system to compensate.

The kinds of pads and their location are provided next. Pads create the droplet size and pattern of their sprinkler system and are directly related to the height of the nozzle at the bottom of the drop hose, in this case 6 feet above the soil surface. The droplet size is important and tied to soil infiltration conditions. Changes in surface litter, crop residues, and stubble removed by burning will alter infiltration and the potential for runoff and soil crusting, and may require pad replacement.

The pressure regulator ensures that correct, constant water pressure is supplied to the nozzle and not altered by changing field elevation. Pressure regulator failure is indicated if the system pressure is correct but the flow rate is excessive. System pressure delivered to the regulator must exceed the pressure regulator setting by 5 psi to correctly function.

Detailed description of the center pivot comprises several pages in the center of the document (Figure 4). Each outlet (plug) on the pipe from the pivot tower to the end of the boom is numbered and described, Acres watered by each tower   Deviation in application rate from design   Design water delivery (inches/hour)

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GPA = 5.48

MINIMUM RECOMMENDED REGULATOR INLET PRESSURE IS 15.00 PSI
WITH GRADUATED ELEVATION OF 10.00 FT THE INLET PRESSURE IS 20.74 PSI FOR SPRINKLER 165
THIS POSITION IS THE CLOSEST TO THE MINIMUM RECOMMENDED INLET PRESSURE
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HYDRAULICS SUMMARY

TOWER NUMBER	ACRES UNDER SPAN	GPM NEED	ACTUAL GPM	PERCENT DEVIATION	GPM PER ACRE	AVERAGE IN. PER HR DELIVERED UNDER SPAN	AVERAGE IN. DELIVERED FOR REVOLUTION TIME 36 HR	48 HR	60 HR
1	1.84	10.06	18.60	85%	10.13	0.022	0.81	1.07	1.34
2	5.39	29.52	29.65	0%	5.50	0.012	0.44	0.58	0.73
3	8.95	48.99	48.42	-1%	5.41	0.012	0.43	0.57	0.72
4	12.50	68.46	67.28	-2%	5.38	0.012	0.43	0.57	0.71
5	16.06	87.93	86.32	-2%	5.38	0.012	0.43	0.57	0.71
6	19.61	107.40	105.67	-2%	5.39	0.012	0.43	0.57	0.71
7	23.17	126.86	125.11	-1%	5.40	0.012	0.43	0.57	0.72
8	22.77	124.65	122.43	-2%	5.38	0.012	0.43	0.57	0.71
OVERHANG	8.15	44.62	47.06	5%	5.78	0.013	0.46	0.61	0.77
TOTAL	118.43	648.50	650.56		5.49				

Figure 5. *Hydraulics Summary.*

including the spacing, distance from the pivot point tower, orifice size, sprinkler pad, and the length of the drop. Measurement units are given in feet.

The first spacing number (last outlet column) is the distance of the first operational outlet from the tower. In this example, the first outlet is 44 feet from the tower. Drops are longer in the middle of each span due to the arch of the boom between towers and an average drop length is given. Clearance between the bottom of the drop and the ground is dependent on the size of tires and length of regulator/nozzle assembly. If there are pressure or flow rate problems with the irrigation system, it may be necessary to change orifices to correct the problem.

tires is 12.83 feet at the tower. A Xi-Wob wobbler head sprinkler with a regulator is 11 inches in length. The required drop hose length is 54 inches just before tower 1.

Following the detailed section of the documentation is a hydraulics summary that provides information on how many acres each span waters, and the average water delivery in inches per hour if the system is performing as designed. The deviation from the design standard indicates how evenly the water is being applied. In this example, the first tower is heavily overwatering, and the other towers are slightly underwatering. This section is followed by an installation instruction sheet (not shown).

An irrigation system is composed of many parts, all of which must work together to provide effective and efficient crop watering. Change to any part of the system may require recalibrating of multiple parts of the system to achieve good performance. By understanding how the pivot works and how each design element affects other parts of the system, an irrigator can make periodic adjustments to keep the system fine-tuned and functioning correctly. Contact the NRCS for technical service providers or K-State Research and Extension irrigation specialists for assistance in assessing your irrigation system.

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