Factors Affecting the Results for Lower Quarter Distribution Uniformity from Catch Can Tests

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Introduction

One of the current Turf and Landscape Irrigation Best Management Practices published by the Irrigation Association states that lower-quarter distribution uniformity (DU_{LQ}) should be a minimum of 55% for spray heads and 70% for rotor heads. As water purveyors begin to adopt the BMPs for use in their local jurisdictions and perhaps require catch-can field tests to verify compliance, there appears to be a need to provide guidelines for performing field evaluations. This paper will look at several factors that affect lower-quarter distribution uniformity from catch-can tests results including wind speed, operating pressure and placement of the catch-cans in the test area.

Currently the Irrigation Association has proposed guidelines for performing catch-can tests which are listed on their website at www.irrigation.org. Some of these guidelines include a minimum number of catch cans to be used for a "valid" test depending on the number and type of sprinkler heads, how far apart the catch-cans are spaced especially in large area rotor installations and the maximum wind speed.

The purpose of the guidelines is to help establish a more uniform procedure to evaluate sprinkler head performance in the field. Currently there are no standards for how the catch-cans tests are to be performed so the guidelines are offered as a way to provide consistency among auditors who perform the tests and may have to certify the compliance of a sprinkler system with the BMPs that have been adopted as standards in many locations.

Audit procedures

The sprinkler audits were performed on three different test areas established at the Outdoor Laboratory for Landscaping and Irrigation Education at the Northern Colorado Water Conservancy District headquarters in Berthoud, Colorado. The test areas are large turf plots of Kentucky bluegrass measuring 70 feet by 100 feet with slope measuring about 1.3%. The soil is a heavy silty clay loam. The sprinkler heads are of various manufacturers installed on square spacing 35' by 35' on center. Each plot requires 12 sprinkler heads to cover the area. Two of the heads utilize full circle arcs and are on their own valve and can be operated independently of the part-circle sprinkler heads. Each valve has a pressure regulator and water meter. A Windtronic

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hand-held anemometer was set up on a tripod to measure wind speed during the audit process. The anemometer could measure the maximum wind speed as well as average the wind speed every five seconds during the test. These values were recorded along with water meter readings and operating pressures.

Various types of catch cans were used to perform the audits. Typically the CalPoly style catch can was used with the metal stand. The throat of the catch- can is an area of 16.5 square inches. A few audits were done using a new style catch can made by the US Bureau of Reclamation, which has a throat area of 14.2 square inches. This particular catch can has self-contained legs and the third style of catch can are in expensive plastic cereal bowls which are low profile and lay on top of the grass or can be pushed down into the turf. They are approximately 5.5 inches in diameter and have a throat area of 23.76 square inches. Usually these bowls were used at the same time as the other catch cans to run two tests at the same time. All of the readings were done in milliliters.

The catch cans were laid out following two methods.

a) The traditional IA methodology as taught in the Certified Landscape Irrigation Auditor training class (and is likewise taught in other similar programs) that is "at or near the head and half-way in between". This method required 35 catch cans and created a grid of cans @ 17.5 feet apart.
b) The "grid method" which uses a regular placement of catch cans spaced a certain distance apart irrespective of the sprinkler head location. The grid arrangement was 8 feet by 9 feet and utilized 99 catch cans. The perimeter catch devices were placed 2.5-3.0 feet from the edge.

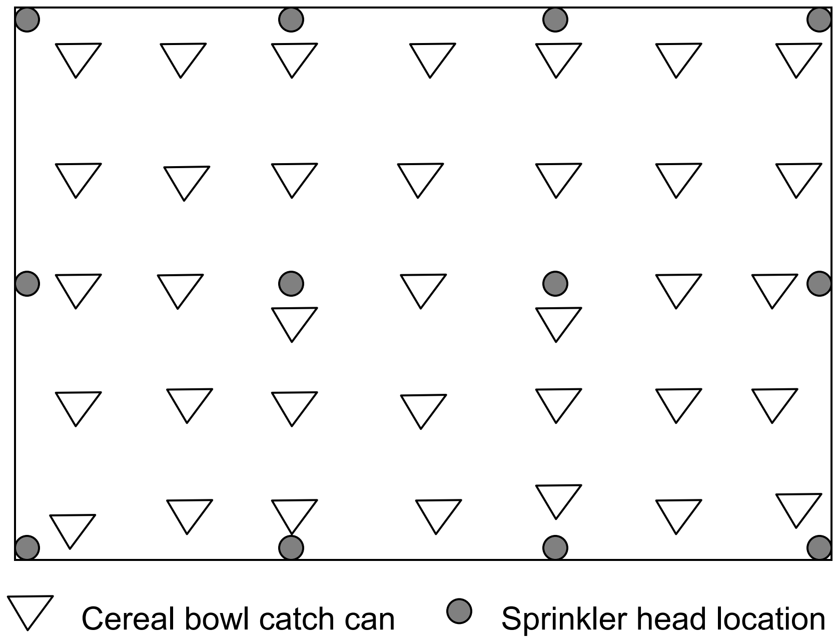
Any catch cans that were near a sprinkler head were recessed into the ground so that the water from the sprinkler heads could fall into the catch device without hitting the side of the device. Both methods were set up to perform the audit test simultaneously with the same water pressure and wind.

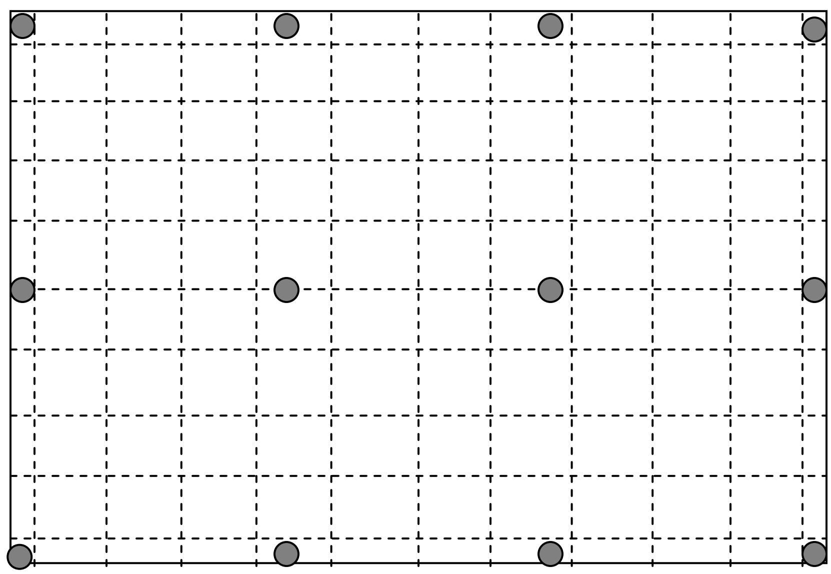
Results

Fifteen audits were conducted on the three demonstration areas over the period of several weeks. Adopting the IA guideline regarding wind speed, no audits were done when the wind speed averaged more than five miles per hour. The results are for three factors that can influence the outcome of an audit including placement and number of catch devices, wind speed, and operating pressures. The results displayed in the following tables came from the audits using the grid method for laying out catch devices.

<u>Catch-can Placement</u>

The quantity and placement of the catch cans in the field tests proved to be significant. Because the plots were identical in shape and size, a procedure was established using tape measures so that the catch-cans could be placed in approximately same spot for each audit. For the traditional IA method, the cereal bowl catch cans were used and placed near each head and halfway between the heads as shown in the following diagram.





The intersection of the dashed lines indicates a catch-can location.

The results from the fifteen audits performed comparing the “grid” audits to a traditional catch can placement of “at the head and half-way between” is shown on the following table. This includes all audits at different operating pressures and wind conditions.

Comparison of DU_{LQ} % between “grid” and “traditional” methods

Grid Method	Test Number	Traditional
60	1	65
39	2	42
75	3	67
61	4	48
69	5	55
66	6	54
63	7	61
65	8	68
68	9	60
66	10	55
63	11	54
55	12	51
68	13	60
59	14	48
67	15	61
62.9	Average	56.6

Thirteen of the fifteen tests showed a better DU_{LQ} for the gird method of auditing compared to the traditional audit method performed on the demonstration plots. Data presented are from a relatively few tests and the results are not conclusive, however the more catch-cans used the better the evaluation would be. The random low or high readings would have less impact on the overall results. The down side to using the grid method is the time it takes to perform such evaluations however if the sprinkler zone would pass the minimum requirement that is better than having to spend time to modify the sprinkler zone and re-test it.

Wind

To demonstrate the affects of wind upon the resulting lower-quarter distribution uniformity (DU_{LQ}) four tests could be used for comparison and is as follows:

	Pressure psi	Avg. Wind Mph	Max. Wind Mph	DULQ %
Plot A	**40**	**.8**	**4.9**	**61**
	40	**2.1**	**6.7**	**52**
Plot C	**50**	**2.1**	**6.1**	**66**
	50	**4.0**	**9.3**	**55**

As can be seen that even though the average wind speed was within the guidelines the impact upon the resulting DU_{LQ} shows about a 15-20% difference in the results for a specific sprinkler head.

Operating Water Pressure

For Plot A the recommended operating pressure for the nozzles selected for the sprinkler head is 50 psi. The results from 4 different audits where the water pressure was changed showed a significant impact on the DU_{LQ} for this particular head and nozzle combination. The full circle heads used the same nozzle as the half-circle heads and required twice the number of minutes of run time to achieve matched precipitation rate.

For Plots B & C the same sprinkler head was used but each had different nozzle combinations. Plot B the nozzles are matched precipitation rate and in this case the full circle heads can run at the same time as the part circle heads. In Plot C the matched precipitation rate is achieved using time, meaning that the full circle heads needed to run for twice as long as the part circle heads. The same nozzle was used for both the full circle and half circle sprinkler heads. The quarter circle nozzles had half the flow rate as the half-circle nozzles and would run on the same circuit or zone. For this particular head the pressure variation did not have as much effect on the Distribution Uniformity but there was definitely more impact upon the average precipitation rate.

Lower Quarter Distribution Uniformity at Various Pressures

	50 psi	45 psi	40 psi	30 psi
Plot A	75	69	61	39
Plot B		65		68
Plot C	66	67	68	63

While the results are not conclusive, it does illustrate the importance of proper operating pressure to get the desired results of optimal performance. A field observation of Plot B was that over an extended period of time while operating at 30 psi that the edges and corners of the plot showed severe signs of stress. After a period of time when the pressure was adjusted back to the preferred 45 psi the stressed areas improved.

While pressure has a definite impact upon the distribution of water from the sprinkler head nozzle there is a substantial change in the net precipitation rate. The results from the audits for the above mentioned plots and sprinkler zones and at the various operating pressures can be seen.

Average Net Precipitation Rate in Inches Per Hour

	50 psi	45 psi	40 psi	30 psi
Plot A	.55	.44	.45	.40
Plot B		.40		.34
Plot C	.62	.53	.56	.47

While the change in precipitation rate caused by changes in pressure and can be significant the bigger impact is the change that needs to be made to the run time on the controller to apply the correct amount of water. In the field observation mentioned before the pressure was reduced to 30 psi to perform the test and not re-established at the preferred operating pressure of 45 psi. Although the uniformity did not change substantially in this case, the resulting change in a lower precipitation rate was not compensated for with changes to the run time on the controller. Therefore, deficit irrigation was taking place over a fairly long and hot spell during the summer before the mistake was caught.

Conclusions

Obviously there are many factors that can affect the distribution uniformity of sprinkler heads working together to irrigate an area such as arc adjustment, height and tilt of the sprinkler head, hydraulics etc. The focus of this small study was to look at other factors besides maladjusted heads such as wind speed, operating pressure and the number and way catch devices are set out to perform a catch can test.

While the results of these few tests provide insight into how different factors influence the outcome of a catch-can test for lower-quarter distribution uniformity they are not conclusive. More such audits in different conditions need to be done. Common sense tells us that if the wind is blowing the results will be varied. What was surprising is how big a difference can be made in the audit results with only a minor change in wind speed even when the wind speed was within the proposed audit guidelines of less than five miles per hour. Obviously more audits documenting the results of changing the operating pressure needs to be done. Most likely the results will become product specific and may not necessarily be applied across the board to all sprinkler heads and nozzles. However, striving to operate the sprinkler head at the recommended pressure for the intended spacing of the sprinkler heads should yield the best results for uniformity. Usually the manufacturers will state that the preferred operating pressure is the middle values or the bolded values on their tables in their product catalogs.

Frequently the traditional methodology of placing a catch device “at or near the head and half-way in-between” is in reality the minimum number of catch devices that should be used and not the absolute number or placement of the catch cans. From the audits that were performed, the grid method using a closer spacing and more catch devices seemed to improve the overall results for measuring lower-quarter distribution uniformity. Since catch can audits represent a snap-shot of how the sprinkler system was performing at that moment, it is expected that a follow-up audit with the catch cans set up in a very similar pattern would produce results that would be within 10% of each other, either above or below the first audit. If the results fall within that parameter then the audit results should be fairly reliable. If the results are more than that, then it would cause concern about the validity of the catch-can tests and which was the most correct.