PRECISION™ SERIES SPRAY NOZZLES

Independent, 3rd Party Test Data Supporting The Conclusion That Toro Precision Series Spray Nozzles Deliver Distribution Uniformity Greater Than Or Equal To All Rotating Nozzles Currently Rebated By Metropolitan Water District

Toro Irrigation
5825 Jasmine Street
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Executive Summary

Oscillating Stream Technology

Toro Precision™ Series spray nozzles use a high-frequency, oscillating stream technology to achieve a low, one-inch-per-hour precipitation rate across all models. Remarkably, these Precision Series spray nozzles perform at flow rates 35% - 42% lower than the flow rates of the most popular spray nozzles currently on the market and installed in the ground. And yet, Precision Sprays cover the same arc and radius of the conventional spray nozzle being retrofitted. Moreover, the model designations of the new Precision spray nozzles have a 1:1 relationship with the spray nozzles being retrofitted – making it easier for the end user to perform a retrofit. Example: A Toro Precision O-12H nozzle replaces a Rain Bird 12H nozzle – the "O" in the Toro model representing One-Inch-Per-Hour application rate.

Watering Schedule Advantage vs. Rotating Nozzles

In addition to the 1:1 retrofit relationship, field tests have shown that under most conditions, the end user does not need to change the watering schedule on his or her controller at the time of the retrofit. This is because the reduced flow and application rate of the Precision spray nozzle system is counterbalanced by the increased irrigation efficiency: improved uniformity, better defined edges, more consistent size and velocity of water droplets and 1"/hr application rate vs. 1.6"/hr application rate which avoids soil saturation and maintains a more favorable balance of oxygen, moisture and nutrients in the soil. Together, these benefits eliminate the need to double station run times as required when retrofitting conventional spray nozzles with rotating nozzles.

Test Results

The information in this notebook is divided into six sections and provides independent, comprehensive support for Toro's position that its Precision Spray Nozzles deserve to be included in the MWD Rebate List of high-efficiency nozzles. Each section includes an explanation of the test performed, its purpose, an outline of the procedures followed and the results. While all the sections are important, the first section contains uniformity test results from CIT, the Center for Irrigation Technology, which is the recognized authority for uniformity testing. The results strongly support Toro's position for inclusion in the Rotating Nozzle Rebate List issued by the Metropolitan Water District.

Test Overviews

SECTION 1: Center for Irrigation Technology

The Center for Irrigation Technology (CIT) conducted a study comparing the distribution uniformity (DU_{LQ}) of currently rebated rotating nozzles and the new Precision Series spray nozzles in the 5'-15' performance range. The average DU_{LQ} for all Toro Precision Spray nozzles tested = 69.9%; for all Hunter MP Rotators tested = 54.4%; for all Rain Bird Rotary nozzles tested = 50.0%. In addition, even the absolute lowest DU_{LQ} measurement for one 15' Precision Spray nozzle was higher than the highest DU_{LQ} measurement for any Hunter MP Rotator - the most rebated rotating nozzle in Southern California.

SECTION 2: Case Study – Irrigation Green & Industry News

The premiere irrigation magazine for the industry published its own case study in its July 2009 issue. The study compared in-field performance of Hunter MP Rotators, Rain Bird 1800 Series Sprays and Toro Precision Series Sprays. The IA Certified Landscape Irrigation Auditor who conducted the DU tests stated, "The Precision Sprays were the most efficient, coming in with a DU of more than 80%. That's a pretty amazing number."

SECTION 3: Urban Water Conservation

Urban Water Conservation, an organization that specializes in irrigation audits and landscape water management consulting, performed a total of seven studies on municipal installations throughout the greater Los Angeles area. The results showed that the Precision spray nozzle systems achieved up achieved up to an 85% DU_{LQ} and had noticeably less misting than the other nozzles that were tested.

SECTION 4: Valley Soil, Inc.

Valley Soil conducted three separate audits comparing Rain Bird's MPR nozzles, Hunter's MP Rotator, and Toro's Precision Series spray nozzles. Their findings revealed that the MP Rotator required the run times to be significantly increased in order to apply an adequate amount of water. Precision spray nozzles, on the other hand, were able to operate with the same or even shorter runtimes due to their effective, 1" per hour precipitation rate and high overall irrigation efficiency.

SECTION 5: The Sixty Day Challenge

A number of commercial and municipal sites were offered the opportunity to participate in a "Sixty Day Challenge" to see if two adjacent spray zones – conventional vs. Precision – could operate under the existing, conventional irrigation schedule and maintain the health and appearance of the turfgrass or landscape. The listed participants achieved water savings from 25% - 30% with the Precision Series spray nozzle zone without compromising their landscape.

SECTION 6: New Mexico State University

New Mexico State University performed eight different distribution uniformity tests on the fifteen-foot Precision spray nozzles. The results of their testing showed a DU of over 80% in all but one of their test plots. To quote Bernd Leinauer, Ph.D., of NMSU, "We have not seen such a uniform irrigation from any of the other spray heads or MP Rotators that we have used in the past. We are very impressed by the performance of these Precision Series Spray Nozzles."

SECTION I

The Center for Irrigation Technology

Toro Precision Series Spray Radius and Distribution Test Procedure

1. Mount the nozzle on a riser located approximately 4” above the plane of the catch cans. Alternatively, mount the nozzle on a 4” sprinkler level with the plane of the catch cans.

2. Align the left arc edge of the nozzle with the edge of the catch can grid if applicable.

3. Manually start test fixture at 30 PSI, inlet.

4. Adjust the nozzle orientation to capture the desired arc of spray (center the spray over the collectors).

5. Allow the sprinkler to run at 30 PSI for a minimum of 15 minutes or until a catch can is filled to capacity.

Precision™ Series Spray Nozzles

MP Rotator Radius and Distribution Test Procedure – 180 Degree Arc

I. Setting the Arc – Maximum Radius

1. Mount the nozzle on a riser located approximately 4” above the plane of the catch cans. Alternatively, mount the nozzle on a 4” sprinkler level with the plane of the catch cans.

2. Align the left arc edge of the nozzle with the edge of the catch can grid.

3. Verify radius adjustment screw is backed out fully – not restricting flow.

4. Set the arc to the approximate desired angle (180 degrees).

5. Manually start test fixture at 40 PSI, do not collect the water or resulting data from manual operation.

6. Adjust arc adjustment ring clockwise to increase arc (flow) or counterclockwise to decrease arc (flow) in order to achieve specified flow rate per catalog (see catalog sheet Reference H-01 attached).
    - MP1000 – 0.37 GPM (14’ radius)
    - MP2000 – 0.74 GPM (19’radius)

II. Testing at Reduced Radius

1. Retain sprinkler orientation and arc setting from Maximum Radius Test.

2. Manually start test fixture at 40 PSI, do not collect the water or resulting data from manual operation.

3. Drive down the radius adjustment screw to achieve the specified flow rate corresponding to requested radius, per manufacturer’s specification sheet (included – specification sheet Reference H-02). If the lower flow rate is not achievable, adjust sprinkler inlet pressure to 30 PSI and adjust radius adjustment screw again to match the specified flow rate corresponding to the requested radius. Make note of test pressure for each test.

4. Perform Radius and Distribution tests.

5. Repeat for each requested radius. If the flow rate cannot be achieved as stated on the reduced radius specification sheet (See Reference H-02 attached) and after reducing pressure to 30 PSI, record the actual flow rate and complete the test.

SECTION II

Case Study – Irrigation Green & Industry News

SECTION III
Urban Water Conservation

URBAN WATER CONSERVATION

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FIELD UNIFORMITY TESTS ON BOWLES FLUIDIC SPRAY NOZZLES, RENAMED PRECISION NOZZLES CONDUCTED FOR TORO CORPORATION

May 8, 2008 tests:
This is a basic test of the nozzles in a typical field site. Two zones were tested, both in center medians on citrus Avenue, in Fontana, California. Present at the test were Mike Baron of Toro Corporation, the designers of the nozzles from Bowles Fluidics, representatives of Fontana public works, Mario Martinez from Fontana Water Company, and Laurence Budd, CLIA from Urban Water Conservation.

Site: Center medians on Citrus Ave. in North Fontana, just south of the 210 freeway. These newer medians are covered with dense groundcover and young trees, both have a prevailing slope of approximately 5 degrees. The weather on the date was clear, light breezes under 8 mph.

Site 1: Median width 18 feet at widest point, narrowing to 15 feet at north end. The Toro 570 spray heads are spaced at 12 feet along the curb edges. The heads are consistently spaced, except for a supplemental row of heads at the south end of the median. The Bowles staff installed 15 foot 180 degree nozzles in the existing bodies. One zone, number A16, covers this entire test area section.

Uniformity Test Data:
24 cups were placed at random exposed spots within the irrigation zone. Cups were placed level, in exposed areas, not below overhanging plant material. Because of the existing 12 foot spacing and 15 foot nozzles, the H2H [head to head] coverage was averaged at 120%. The heads were run for a continuous period of 10 minutes. Each ASTM cup was then measured for volume of water. Results were multiplied by 6 to obtain average hourly precipitation rates.

Average precipitation rate: .99 inches per hour
Distribution Uniformity, lower quarter: 63%
Range of application rate: .48 to 1.32 inches per hour
Dynamic pressure at heads: 48 psi

Site 2: Median further south along Citrus Ave. Average 10 foot width, narrowing to 4 feet at the north end. Existing heads spaced at 10 feet. Bowles installed 15 foot fluidic nozzles. This

median has the same dense ground cover, young trees and prevailing slope as site number 1. One zone, number 1, covers this entire area.

Uniformity test data:
20 cups were placed at random exposed spots within the irrigation zone. Cups were placed level, in exposed areas, not below overhanging plant material. Because of the existing 10 foot head spacing and 15 foot 180 degree nozzles used for this test, the resulting H2H was 150%. The heads were run for a continuous period of 10 minutes. Each ASTM cup was then measured for volume of water. Results were multiplied by 6 to obtain average hourly precipitation rates.

Average precipitation rate: 1.67 inches per hour
Distribution Uniformity, lower quarter: 59%
Range of application rate: .60 to 2.4 inches per hour
Dynamic pressure at heads: 50 PSI

Commentary:

It was noted by all parties that the nozzles had good pattern of application and no misting. There was some wind drift caused by the breeze. The droplet size appeared visually to be larger than that of a standard spray nozzle. The angle of spray appeared to be below 30 degrees. The higher application rate on test #2 was due to the 10 foot spacing of the existing heads and the large degree of overlap caused by using 15 foot nozzles. It would be good to retest the same zone with 12 foot nozzles. During the test periods, no runoff or pooling was observed.

Retest of site #2 above, on March 3rd, 2009.

We set the same cup spacing as for the previous test. Again, this area is a 12 foot wide median, with Toro 570 heads down both sides, at 10 foot spacing. The fluidic- now called precision- nozzles are 15 foot version, therefore creating a 150% head to head pattern.

The Weather was calm and dry, 24 ASTM cups evenly spaced through one zone, wholly within that zone. 10 minute test. This entire median section is one zone.

Uniformity test data:
Average precipitation rate: 2.4 inches per hour
Distribution uniformity, lower quarter: 71%
Range of precipitation rate: 1.3 to 3 inches per hour
Dynamic pressure at heads: 48 PSI

Comparison zone test:

Center Median on Baseline, 1 block away from previous area. 10 to 12 foot width, test wholly within one zone. 10 and 12 foot nozzles. Same runtime settings, Toro 50 bodies, regular series Toro spray nozzles.

Uniformity test data:
Average Precipitation rate: 1.5 inches per hour
Distribution uniformity, lower quarter: 53%
Range of Precipitation rate: .6 to 2.4 inches per hour
Dynamic pressure at the head: 40 PSI
Note: This area consists of low xeric shrubs on bare rocky soil. The precipitation rate and DU_{LQ} are more a reflection of blockage of spray pattern than head performance.

Retest of same area in Fontana on April 2, 2009:

Center median on Citrus, 15 foot precision nozzles at 10 foot spacing down both sides, 150% head to head coverage. Light breeze, under 8 mph, caused by passing traffic. 24 ASTM cups, 10 minute test, evenly spaced wholly within one zone, same spacing as previous tests.

Precision nozzles Uniformity test data:
Average precipitation rate: 2.11 inches per hour
Distribution uniformity, lower quarter: 57%
Range of Precipitation rate: 1.2 to 3.3 inches per hour
Dynamic pressure at the head: 48 PSI

Same area replaced with standard Toro 12 foot nozzles, same cup pattern, etc:

Toro spray nozzle uniformity test data:
Average precipitation rate: 2.13 inches per hour
Distribution uniformity, lower quarter: 79%
Range of precipitation: 1.2 to 3 inches per hour
Dynamic pressure at the head: 48 PSI

Test at city of Irvine, March 3rd, 2009, center median on Main St.

Two identical center median zones were tested at this site. The center medians are 15 feet wide, turf with trees, with spray heads on both sides at 10 foot spacing, plus heads in the center, also at 10 foot spacing. This is significant in the test results. The weather was calm and dry, no appreciable breeze. Traffic was very light.

First Test, Toro precision nozzles, 15 foot halves and fulls. zone # 18 on the controller. 10 minute test, 24 ASTM cups evenly spaced wholly within 1 zone. Zone consists of 43 half and full spray heads.

Toro Precision nozzles uniformity test data:
Average precipitation rate: 2.75 inches per hour*
Distribution uniformity lower quarter: 78%
Range of precipitation rate: 1.8 to 3.3 inches per hour
Dynamic pressure at the head: 50 to 52 PSI

Comparison test, adjacent zone # 17. Rain Bird 1800 series nozzles, 15 foot halves and 12 foot fulls, same cups and spacing as above. 10 minute test.
Rain Bird 1800 nozzle Uniformity test data:

Average precipitation rate: 3.54 inches per hour*
Distribution uniformity lower quarter: 67%
Range of precipitation rate: 2.1 to 6.6 inches per hour
Dynamic pressure at the head: 50 PSI

*Note: These zones have too many heads vs. area, causing a much higher application rate than spec. It was noted that comparing the test areas of 2250 square feet vs. the 43 half and whole heads per area showed the rates are correct for a Rainbird 1800 application rating of 1.6 inches per hour and a Toro precision rating of 1.2 inches per hour.

Test at city of Lake Elsinore, School district, Ronald Reagan elementary school. April 2nd, 2009

Three different zones were tested, Precision, Rain Bird 1800 and hunter MP heads. Smart dial ET based controller, therefore runtimes are not fixed. The weather was dry with a light breeze. Due to location, the MP rotator zone had a stronger breeze than the other zones.

Test of Toro precision nozzles in turf area at the north end of the parking lot and property edge, 15 foot grid spacing, 15 foot quarter, half and full nozzles. 24 ASTM cups randomly set wholly within one zone. 10 minute test.

Average precipitation rate: 1.4 inches per hour
Distribution uniformity, lower quarter: 85%
Range of precipitation rate: 1.2 to 2.4 inches per hour
Dynamic pressure at the head: 47

Test of Rain Bird 1800 series nozzles, in 10 foot wide strip, at 10 foot spacing. Turf strip area at the front entrance of the school. Most nozzles 12 foot halves. 24 ASTM cups randomly set wholly within one zone. 10 minute test.

Average precipitation rate: 2.25 inches per hour
Distribution rate lower quarter: 57%
Range of precipitation rate: 1.2 to 3.6 inches per hour
Dynamic pressure at the head: 47

Test of Hunter MP heads , in a 10 foot wide strip, 8 to 10 foot spacing. Turf strip area at the front of the school. We had to change the nozzles before conducting the test, as most of the nozzles were MP2000 90-210, over-spraying 10 feet onto hard surfaces. Replaced with MP1000 and MP side strip nozzles. Heads still placed too close. Also shut off several full circle Rain Bird 1800 series within this zone, not needed for head to head coverage, and conflicting application rate. 24 ASTM cups randomly set wholly within one zone, 10 minute test.

Average precipitation rate: .92 inches per hour
Distribution rate lower quarter: 60%
Range of precipitation rate: .3 to 1.2 inches per hour
Dynamic pressure at the head: 47

Tests at Winchester California, residential site, April 5th, 2009

Test of Toro precision nozzles in Toro 570 bodies. Small spray zone, 15 foot nozzles at irregular spacing, from 8 to 13 foot spacing. Nozzles have been turned down for overlap. 19 ASTM cups randomly set wholly within one zone. 15 minute test.

Average precipitation rate: 1.1 inches per hour
Distribution rate lower quarter: 71%
Range of precipitation rate: .8 to 1.8 inches per hour
Dynamic pressure at the head: unknown- at 40 or below

Test of Hunter MP nozzles in Toro 570 bodies. 12 to 17 foot spacing, mostly MP2000 series. 20 ASTM cups randomly set wholly within one zone. 15 minute test.

Average precipitation rate: .72 inches per hour
Distribution rate lower quarter: 72%
Range of precipitation rate: .4 to .96 inches per hour
Dynamic pressure at the head: unknown- at 40 or below

Observations on tests:

1. The application rates and uniformity of the Toro precision nozzles appears to be best when the spacing is correct for the given nozzle. In this scenario the application rate is close to the design spec and uniformity is high.
2. The uniformity of the Toro precision nozzles appears to drop when the head spacing is uneven, or too tight for the nozzle size, as in the tests in Fontana where there were 15 foot nozzles at 10 foot spacing.
3. The application rate of the precision nozzles in the Fontana test median had risen in the 2009 tests, at a consistent dynamic 50 PSI . This may be due to some opening of the dampening screw over time. I would like to suggest testing several other precision sites over time to determine if this is a pattern.
4. All of the tested precision zones showed less misting and larger droplets compared to standard Toro 570 and Rainbird 1800 nozzles.

SECTION IV

Valley Soil, Inc.

Water Audit: 4/29/2008
Elsinore Valley Municipal Water District

Three separate audits were conducted at and sponsored by the EVMWD to compare the existing Rainbird MPR spray nozzles to MP Rotator nozzles to Toro Precision nozzles from 11AM to 12:30 PM on 4/29/2009..

The wind was consistent for each test: 0 to 3mph and only intermittently.

All catch cans were placed in the turf on a measured 10 feet apart, 2 ½ feet off the sidewalk edge so as to not interfere with 2 air vacuum stand pipes, 1 foot off a planter edge in the back and centered at 7 ½ feet in the middle of the 15 foot wide measured turf area. The cans were spaced at a triangular offset but not at a true 45 degree offset from each other.

Each can location was marked individually prior to testing so that each can would be replaced in the exact location for each of the 3 tests. This was done using 2 ¾" white golf tees. These will be recycled for a good use.

Head spacing was inconsistent as noted on the audit forms.

The Rainbird MPR test required no head/ nozzle modifications and was conducted as found in the field.

The MP Rotator test required that we attached a Rainbird PA-80 Rainbird thread X ½" MIPT adapter to the existing 1800 series pop up nozzle threads then adds Toro 570S shrub adapter on top of the PA-80. This was done so that the increased nozzle elevation would be matched for both the MP Rotators and the Toro Precision nozzles. About 2" in height was gained. The MP Rotators were MP 1000, 90-210T, "T" standing for Toro threads. The test was conducted with the catch cans in the exact same location as the Rainbird test.

The Toro Precision spray nozzles were tested by attaching them to the PA-80/ 570S combination with the catch cans in the exact same location as the Rainbird test. The MP Rotators and Toro Nozzles were new, not used.

The test was conducted on a recycled water system. The existing valve screens were discovered to be fairly covered in debris from the water delivery system. They were not fully plugged as the system still covered.

All catch cans were read in sequence and per location, the data is included on the form. The test data for each can/ location is the same for each test so that one can's locations, i.e. #5 is #5's location for all tests.

At the end of the test the existing Rainbird nozzles/ filters were replaced. It was determined by a quick calculation that the Rainbird GPH numbers appeared low. So, an operating head pressure test was conducted. One Rainbird nozzle was removed and a gauge was placed on that head. The pressure tested out at 20 PSI.

System delivery pressure was stated to be around 45 PSI, or within accepted limits for each nozzle type. It was stated that the backflow screen appeared not to be maintained according to the owners contract specifications and that all the existing nozzles may need to be pulled to conduct filter screen cleaning for each head.

Test Conclusion and Observation: The MP Rotators faired moderately well but the run times would have to be increased substantially to apply adequate watering. The Toro nozzles however showed that run times could be kept the same or maybe decreased as a result of their PR to DU Ratios. For this system I could not recommend converting to MP Rotators due to inadequate maintenance/ low pressure and I may have the same concerns in regard to other recycled water systems, definitely low pressure areas or maybe pump systems (pump failures).

Submitted by: Eric Anderson, President, Valley Soil, Inc., C.L.I.A. #006244.

SECTION V

The Sixty Day Challenge

60-Day Challenge Participants

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SECTION VI

New Mexico State University

Mike,

Attached please find an Excel spreadsheet with the results of an irrigation audit that we conducted on our test plots. We installed the new Precision Series Spray Nozzles in an experiment that requires uniform water distribution on test plots that measure 20' by 20'. The audit was run 3 times and heads were readjusted and nozzles were cleaned when uniformity was lower than 0.70. The audit was run 3 times and after the last run we concluded that the new nozzles irrigate very uniformly. With the exception of one plot, the nozzles produced DUs greater than 0.80. We have not seen such a uniform irrigation from any of the other spray heads or MP Rotators that we have used in the past. We are very impressed by the performance of these Precision Series Spray Nozzles.

Please feel free to contact us if you have further questions.

Sincerely,
Bernd Leinauer

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WESTERN BLOCK POTABLE

WESTERN ROW	SP1	SP2	SP3
	28	35	50
	30	38	44
	43	40	35
	52	46	32
	50	50	40
	48	49	29
	44	43	35
	35	37	34
AVG	41.25	42.25	37.375
DUlo	29	36	30.5
DU	0.70303	0.852071	0.816054

WESTERN BLOCK POTABLE

WESTERN ROW	SP1	SP2	SP3
	28	28	27
	24	31	29
	17	24	30
	24	29	24
	30	34	26
	41	36	28
	12	26	30
	20	38	33
AVG	24.5	30.75	28.375
DUlo	14.5	25	25.5
DU	0.591837	0.813008	0.898678

WESTERN BLOCK POTABLE

WESTERN ROW	SP1	SP2	SP3
	34	31	22
	34	38	29
	33	35	24
	29	32	20
	36	35	28
	28	36	27
	32	35	25
	27	28	34
AVG	31.625	33.75	26.125
DUlo	27.5	29.5	21
DU	0.869565	0.874074	0.803828

WESTERN BLOCK POTABLE

WESTERN ROW	SP1	SP2	SP3
	28	39	18
	15	29	32
	15	34	33
	15	42	29
	35	30	33
	28	19	34
	36	28	37
	40	27	42
AVG	26.5	31	32.25
DUlo	15	23	23.5
DU	0.566038	0.741935	0.728682

WESTERN BLOCK SALINE

WESTERN ROW	SP1	SP2	SP3
	35	37	42
	31	34	36
	39	23	37
	31	23	38
	36	51	44
	36	37	44
	21	35	36
	20	40	45
AVG	31.125	35	40.25
DUlo	20.5	23	36
DU	0.658635	0.657143	0.89441

WESTERN BLOCK SALINE

WESTERN ROW	SP1	SP2	SP3
	36	53	27
	27	35	33
	40	55	34
	28	40	35
	44	41	40
	36	35	29
	40	37	40
	45	39	42
AVG	37	41.875	35
DUlo	32	35	28
DU	0.864865	0.835821	0.8

WESTERN BLOCK SALINE

WESTERN ROW	**SP1**	**SP2**	**SP3**
	40	60	50
	36	35	45
	40	64	32
	26	37	40
	38	39	43
	31	21	33
	39	25	40
	28	18	32
AVG	34.75	37.375	39.375
DUlo	27	19.5	32
DU	0.776978	0.521739	0.812698

WESTERN BLOCK SALINE

WESTERN ROW	**SP1**	**SP2**	**SP3**
	38	48	33
	40	30	26
	43	43	30
	35	38	37
	51	30	31
	45	27	26
	34	30	31
	38	38	30
AVG	40.5	35.5	30.5
DUlo	34.5	28.5	26
DU	0.851852	0.802817	0.852459