Multi-Stream, Multi-Trajectory Nozzles; How they save water, labor and installation costs

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Abstract. *Irrigating spaces in the 8'-20' range efficiently has always been a challenge in Residential and Commercial applications. Impending Federal and State regulations imposing requirements for minimum levels of efficiency have forced the irrigation industry to seek out and explore new methods and technology to improve the way water is applied. Excessive watering (flood irrigating) has been the practice of irrigating smaller areas since the introduction of brass nozzles many years ago. Irrigating with emission devices, such as spray nozzles, that perform at high precipitation rates has been the status quo for over three decades. However, in the last few years, a new and innovative technology has been introduced in the form of Multi-Stream, Multi-Trajectory (MSMT) rotating nozzles. Introduced by the Walla Walla Corporation with roots back to the stream nozzle, the MSMT nozzles offer performance similar to highly efficient single-stream rotors in smaller radii. In addition, these new nozzles are simple and easy to install on top of existing pop-up sprinklers and propel performance to never before seen water savings. This higher level of performance is accomplished by achieving significantly higher Distribution Uniformities which more closely match soil absorption rates, resulting in a significant reduction of wasteful runoff. Additional benefits of these new nozzles include cost savings to the irrigation contractor upon installation. Case studies have shown contractors can save considerably on overall labor and cost of materials when compared to traditional spray nozzle installations.*

Keywords. Multi-Stream Multi-Trajectory nozzles, Distribution Uniformity, Soil Infiltration Rate, Intake Rate, Soil Texture Class

Never before has the residential/commercial irrigation industry been offered a revolutionary line of products that cover spray applications which break the routine of water wasting and move towards water conservation. This product category is the Multi-Stream, Multi-Trajectory (MSMT) line of nozzles.

This line of products has proven itself to have changed the game when compared with traditional spray heads. First introduced to the commercial irrigation industry in 2005 by Walla Walla Corporation, the MSMT nozzle has changed the way designers and professional contractors think about irrigating smaller areas where typically sprays have been used. MSMT technology has actually been around for some time, but, due to manufacturing challenges, it was not possible to produce a nozzle small enough that could easily be installed or retrofitted on a pop-up spray body. Since the introduction of MSMT nozzles, many major irrigation manufacturers have followed with versions of their own.

MSMT nozzles deliver water to its precise location by using individual streams of water thereby significantly increasing the uniformity of how that water is being delivered. MSMT nozzles are just as they sound, they have differently angled streams which are designated to throw given distances and do not interfere with other streams that place water to other locations.

Distribution Uniformity

Distribution uniformity (DU) measures the evenness with which water is applied to the landscape by an irrigation system (Irrigation Association, 2005). It is measured by conducting an "audit," or catch-can test, of the system (Irrigation Association, 2004). DU calculation is based on the average volume of water caught in catch-cans in the least watered areas when compared to the average volume of water caught in catch-cans in the entire area.

DU_{LQ} (lower quarter) is used to classify the quality of coverage (as related to irrigation water usage) in a fixed spray zone using the lowest quarter as the least watered. Table 1 below is a guideline to be applied to DU's measured in the field and terms them as Excellent, Good and Poor. (Irrigation Association, Landscape Irrigation Auditor, 2007, Table 3-4, page 52):

SPRINKLER TYPE	EXCELLENT (Achievable)	GOOD (Expected)	POOR (if lower than this, consider not scheduling)
Rotary Sprinklers	80%	70%	55%
Spray Sprinklers	75%	65%	50%

Table 1

Increasing Distribution Uniformity (DU) is a key component in decreasing the amount of water that needs to be applied for irrigation purposes. Independent testing as well as manufacturer testing shows that 80% DU is attainable with MSMT nozzles. Below is a simple method that can be applied to DU and plant watering needs.

DU %	Water the Plant needs	÷	DU (decimal)	=	Amount of water needed to apply to keep dry area green
30%	1 in	÷	0.30	=	**3.33**
50%	1 in	÷	0.50	=	**2.00**
70%	1 in	÷	0.70	=	**1.43**
80%	1 in	÷	0.80	=	**1.25**

Table 2

Independent studies have shown that typical irrigation systems utilizing spray nozzles are inefficient (Mecham, 2001). Mecham conducted over 6800 independent audits on spray zones and identified that most systems average 50% in DU. Referencing Table 2

and assuming that most turf in the highest summer demand need 1" water/week, a system that is 50% efficient needs to deliver a total of 2" of water in order to overcome inefficiencies. MSMT nozzles have been tested at Center for Irrigation Technologies at California State University Fresno and have shown that it is reasonable to reach 80% DU. When converting from 50% DU sprays to 80% DU MSMT nozzles in the above scenario, 2" minus 1.25" results in an immediate .75" of water per hour reduction in consumption of water. (Kissinger/Solomon 2005) conducted 13 independent audits for their study of potential water conservation with spray nozzles converted to MSMT nozzles. The average of their spray zone audits was 44% DU_{LQ}. Measuring this off of table 1, all zones were rated poor. On average, conversion to the MSMT nozzles improved DU_{LQ} from 44% to 70% DU resulting in a 37% reduction in water consumption.

Case Study on increased Distribution Uniformity

In June of 2011, a case study was conducted at the Washington State Liquor Control Board Distribution Center to measure Distribution Uniformities of their spray zones. Figure 1 displays the zone which was audited with 15 ft. spray nozzles in the Quarter, Half, and Full configuration with 20 spray heads in total.

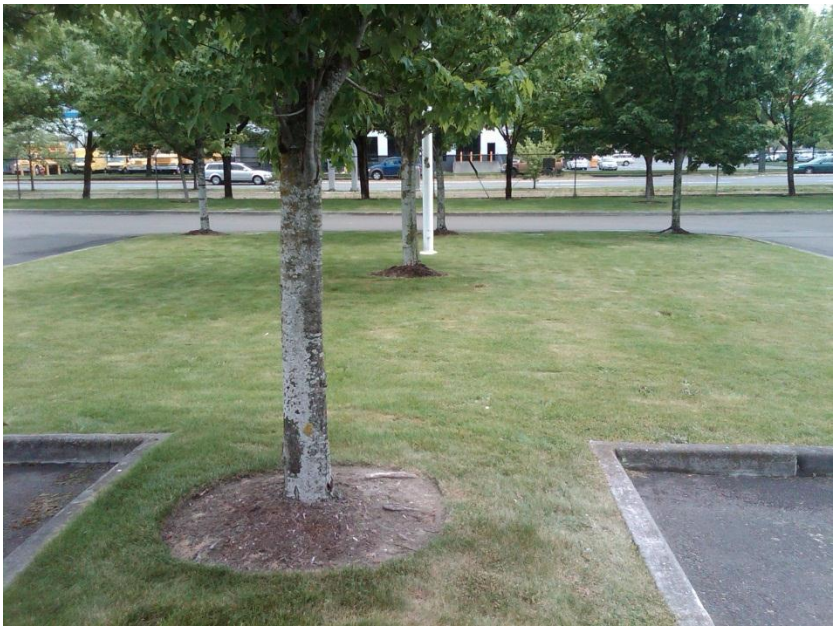

Figure 1

After the system was tuned up with straightening of pop-up sprinklers and cleaning filter screens, the pressure was measured at 25 psi dynamic pressure. A total of 32 catchments were evenly spaced over the entire zone and the audit was conducted for 6 minutes. Once the spray zone audit was complete, the nozzles were removed and MSMT nozzles were installed and adjusted. Pressure was measured prior to the audit at 40 psi dynamic. This increase in pressure was the result of installing a lower flow nozzle thereby maintaining more of the overall system pressure. Catchments remained in place and the audit was run for 10 minutes. A longer runtime was needed due to the lower precipitation rate to fill an adequate amount of water in the catchments.

Results of Audit:

NOZZLE TYPE	PRECIPITATION RATE (PR)	DISTRIBUTION UNIFORMITY (DU)
15' Sprays	1.64"/hour	34%
MSMT Nozzles set to 15'	.50"/hour	**74%**

Table 3

By increasing the Distribution Uniformity and lowering the overall Precipitation Rate, this zone is more evenly applying the irrigation water and at a rate which the soil is capable of absorbing. Distribution Uniformity as seen in Table 3 shows the significant increase from 34% to 74%. The MSMT nozzles will save just this one zone over 50% on water consumption.

Application of Water to Soil Infiltration Rate

MSMT nozzles have precipitation rates (PR) similar to single stream rotors that more closely match typical soil infiltration rates. By applying water at rates less than that of the soil infiltration rate, runoff is greatly reduced. Often misunderstood, soil infiltration rates across the country are usually .5”/hour or less. If water is applied at a higher rate, runoff occurs shortly after the irrigation cycle begins. This is seen in almost all traditional spray installations.

One of the greatest challenges with MSMT nozzles is education and creating the similarity with single stream rotors. It is all too often that the comparison is done with conventional sprays which create additional confusion due to increased run times because of lower precipitation rates. Table 4 is taken from the Irrigation Association’s Landscape Irrigation Auditor course book on soil holding capacities. It is a good idea to make the comparison between the precipitation rate of the sprinkler one will be installing and the basic intake rate (soil infiltration rate) of the soil to be irrigated. Once this has been accomplished, the irrigation installer can now make better decisions on run times for scheduling.

Soil Infiltration Rates	
Soil Texture Class	Basic Intake Rate In./hr.
Clay	**0.10**
Silty Clay	**0.15**
Clay Loam	**0.20**
Loam	**0.35**
Sandy Loam	**0.40**
Loamy Sand	**0.50**
Sand	**0.60**

Table 4

Soil infiltration rate is a measurement of how quickly water will be absorbed into certain soils. Compaction, thatch buildup, and slopes will have a negative effect and reduce the absorption rate. It can be easily seen that if areas are irrigated with traditional sprays with PR's of over 1 ½"/hr. that water will pool and begin to runoff soon after the system is turned on. Most of the soils in the United States fall somewhere in the Sandy Loam and Loamy Sand profile. Even if .6"/hr. is used for a given rate, it becomes evident that regardless of the spray that is used, it will result in an over watering scenario leading to runoff. Excessive watering has been and continues to be the most widely used method of irrigating with spray nozzles. The only way to successfully manage traditional sprays is to use the cycle and soak method of scheduling where short, more frequent cycles of irrigating are used. This method is not widely used due to water window issues and overall length of time required to apply correct amount of water. MSMT nozzles have various PR's, but most fall with .6"/hr. or less. If the Soil Infiltration Rate of a particular soil can be matched, wasteful runoff can virtually be eliminated. Additionally, this lower PR allows for continuous watering, affording the water to be absorbed at the rate it is put down. This does come at an expense to the contractor who is designing the system in the form of longer run times for a particular irrigation cycle when compared with traditional spray nozzle schedules. The math is quite simple, if a certain infiltration rate is to be matched, the water must be put down at a lower rate. If the emission device has a low PR, the runtime must be longer. The benefit however, will result in less water consumption.

Matched Precipitation

MSMT nozzles deliver water at a much higher efficiency Distribution Uniformity (DU) due to unique streams that are dedicated to placing water to precise locations rather than having one spray pattern. In addition to high DU's, MSMT nozzles have low precipitation rates that more closely match soil absorption rates. Most manufacturers' offerings have matched precipitation rates where regardless of the arc or radius chosen, the same amount of water will be delivered over a given area. This is an important feature because most traditional spray nozzles have varying PR's and therefore cause

over and under watering within a single spray zone. By having matched PR's, the installer is ensured the correct amount of water will be applied.

Wind Effects on Application Performance

Poor spray performance in light wind conditions is a problem that every landscape irrigation contractor has faced at one time or another. Traditional sprays emit water from one orifice at a given trajectory. Because of this one orifice, water tends to atomize more readily and is subject to drifting further distances than intended, in many cases off the desired landscape. MSMT nozzles emit water from various trajectories with individual streams that slowly rotate. These streams have higher energy than spray nozzles and can combat light wind applications much easier.

In a test to compare loss of irrigation water in light wind application, it was discovered that traditional spray nozzles accounted for approx. 8.5 times more loss than MSMT nozzles (Kumar 2009). Figure 5 shows the difference in overall loss of gallons due to wind drift. Note the runtime for the Spray Nozzles was significantly less than the MSMT nozzles.

NOZZLE TYPE	RUNTIME (min)	WIND DRIFT (gal)	AVGERAGE WIND SPEED (mph)
Spray Nozzle	19	3.66	2
MSMT Nozzle	30	0.43	1.5

Table 5

Labor and Installation cost savings

Additional benefits of installing MSMT nozzles include installation and labor cost savings. In today's competitive market, providing contractors with the ability to reduce labor costs and materials for a job can be the difference between breaking even and making a profit. The benefit of installing a nozzle with low PR's means the contractor can increase the number of heads per zone thereby reducing the amount of total zones per job. MSMT nozzles also offer greater distance performance (increased radius) compared to spray nozzles, allowing the designer and installer to increase the distance between heads. This gives the contractor the ability to increase the size of the zone to cover more area. Accomplishing all of this can result in a significant reduction compared to traditional sprays, and may also afford the designer and installer the opportunity to reduce the size of the controller, further driving down the cost of overall installation. Figure 2 provides an example of a typical installation utilizing a conventional spray system. Micro zones and climates were not taken into consideration as they would be the same for each application. The goal was to design a system that would successfully grow turf. Figure 3 represents the same site with an irrigation system designed to utilize MSMT nozzles.

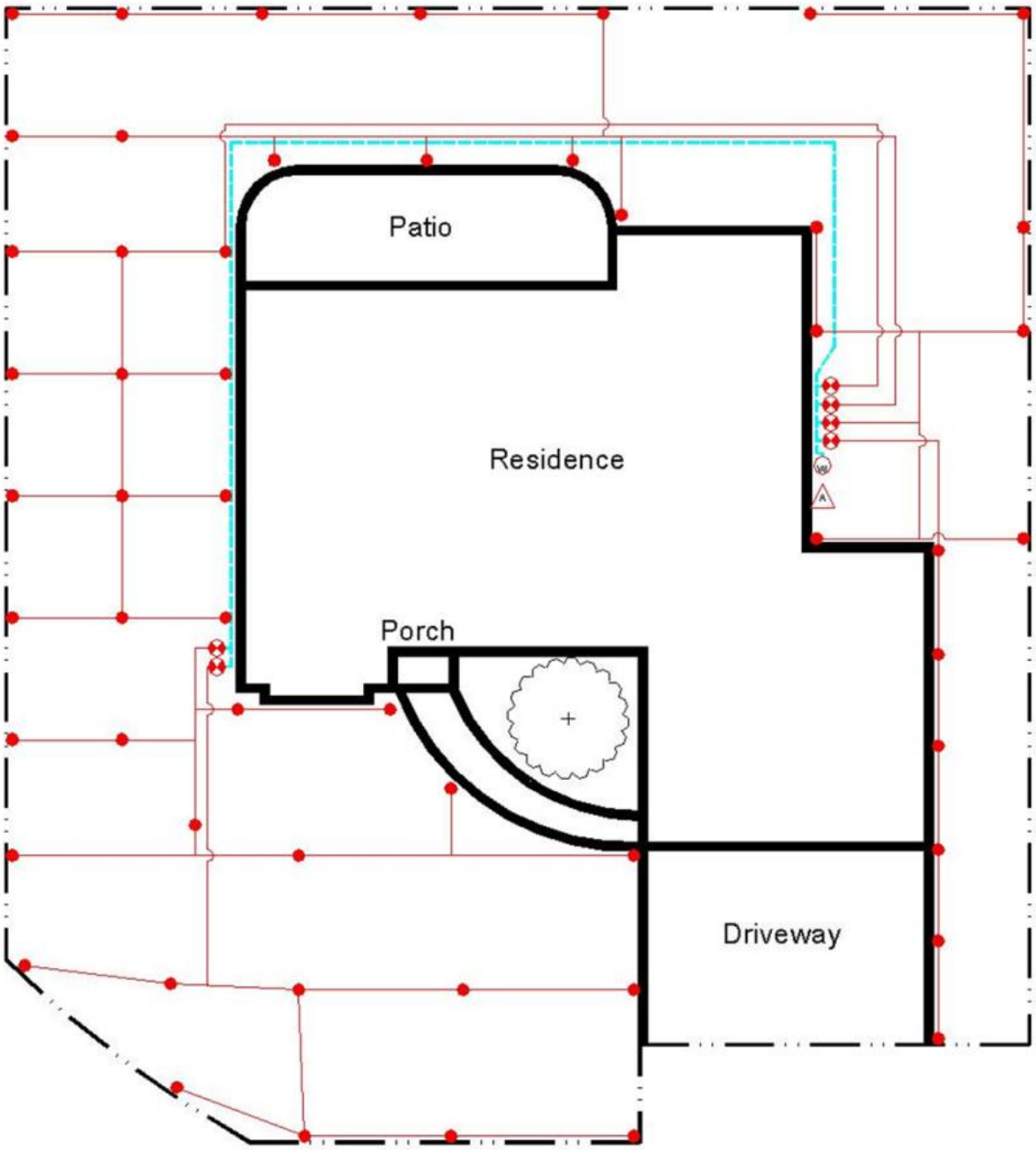

Figure 2
Designed with traditional spray nozzles

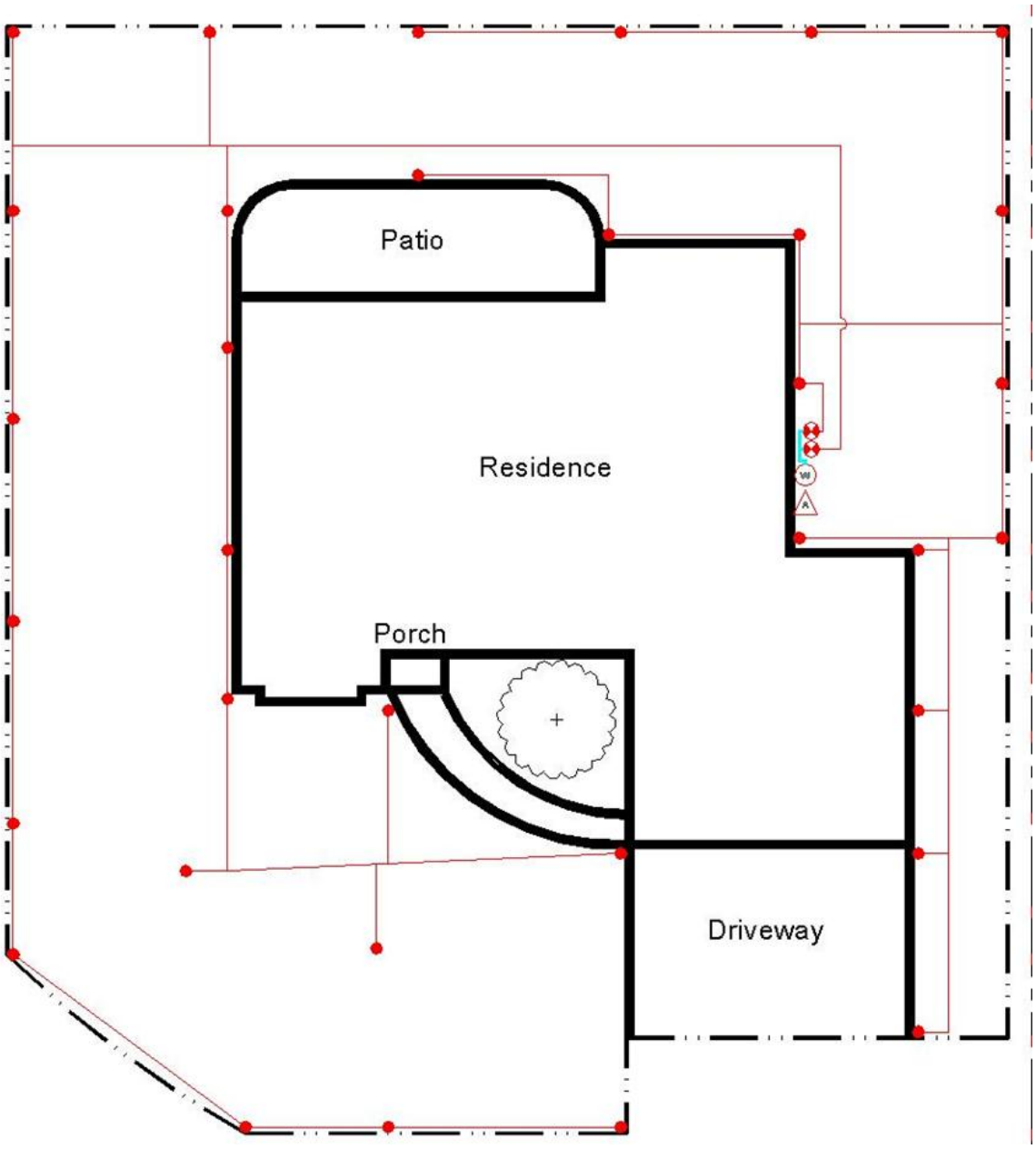

Figure 3
Designed with Multi-Stream, Multi-Trajectory rotating nozzles

When making comparisons to the two designs, the MSMT nozzle design shows how many fewer heads are needed due to the longer radius and lower flow per head option. Additionally, fewer valves were needed in order to accomplish the same coverage. Table 6 provides a simple cost comparison of the two installations:

MSMT nozzles			
	No.	Price per unit	Cost
Valves:	2	$225.00	$450.00
Mainline	15 feet	$2.50/ft.	$37.50
Laterals:	600 feet	$1.50/ft.	$900.00
Sprinklers:	34	$18.00/sprinkler	$612.00
Controller:	3 Station	$225.00	$225.00
Wire:	20 feet	$0.12/ft.	$2.40
		Bid Price:	**$2,226.90**
Water Consumption:		**21.3 GPM**	
		% Savings on Bid:	**45%**

SPRAYS			
	No.	Price per unit	Cost
Valves:	6	$225.00	$1,350.00
Mainline	150 feet	$2.50/ft.	$375.00
Laterals:	800 feet	$1.50/ft.	$1,200.00
Sprinklers:	55	$15.00/sprinkler	$825.00
Controller:	6 Station	$275.00	$275.00
Wire:	175 feet	$0.12/ft.	$21.00
		Bid Price:	**$4,046.00**
Water Consumption:		**77.4 GPM**	

Table 6

The amount of overall material and labor to install the conventional spray system is considerably more costly to the contractor bidding on this job. With some education on the benefits of designing with MSMT nozzles, a contractor can apply that knowledge to improve profitability and competitiveness.

Contractors have identified the benefit of selling their existing customers on MSMT nozzles and retro-fit their already installed systems. Designed so that they can be installed on spray risers, MSMT nozzles make it easy for contractors to improve irrigation system efficiency just by replacing spray nozzles with MSMT nozzles. By conducting simple system tune ups and replacing existing spray nozzles with MSMT nozzles, property owners are able to see immediate savings on their water consumption.

Conclusion

Water conservation is at the forefront of our industry and having Multi-Stream, Multi-Trajectory nozzles as a product offering, allows the gap to be bridged from wasteful spray nozzles to a more efficient method of irrigating. Education continues to be an integral part of promoting this new technology. As regulation forces the residential/commercial irrigation industry to move in the direction of water conservation, low precipitation rate nozzles and higher distribution uniformities will be called upon for future installations. Contractors adopting this new technology have the opportunity to not only install the most water conservative products but can profit from doing so as well. Installing the most efficient product offered in the market place while saving on overall labor and materials costs, the MSMT nozzle category is a winning combination for professional irrigation installers hands down.

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