DOCKETED

Docket Number:	17-AAER-08
Project Title:	Sprinkler Spray Bodies
TN #:	221200
Document Title:	Brent Mecham Comments Proposed Testing of Spray Sprinklers
Description:	N/A
Filer:	System
Organization:	Brent Mecham
Submitter Role:	Public
Submission Date:	9/18/2017 11:27:29 AM
Docketed Date:	9/18/2017

Comment Received From: Brent Mecham
Submitted On: 9/18/2017
Docket Number: 17-AAER-08

Proposed Testing of Spray Sprinklers

Additional submitted attachment is included below.

Spray Sprinkler Bodies Docket Number: 17-AAER-05

2017 Appliance Efficiency Standards

Brent Mecham, Irrigation Association, September 18, 2017

Contents

Purpose **1**

Product/Technology Description **1**

Overview **2**

Methodology **3**

Proposed Standards and Recommendations **4**

Analysis of Proposal **5**

Scope/Framework 5

Product Efficiency Opportunities 5

Technical Feasibility 5

Statewide Energy Savings 5

Environmental Impacts/Benefits 6

Impact on California's Economy 6

Consumer Utility/Acceptance 6

Manufacturer Supply Chain Timelines 6

Other Regulatory Considerations 7

Conclusion **7**

References **7**

Appendices **7**

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, California Code Regulations, §§ 1601 – 1608). This report specifically covers Spray Sprinkler Bodies

Product/Technology Description

Manufacturers have made available for a number of years optional features to improve sprinkler nozzle performance and to reduce water waste.

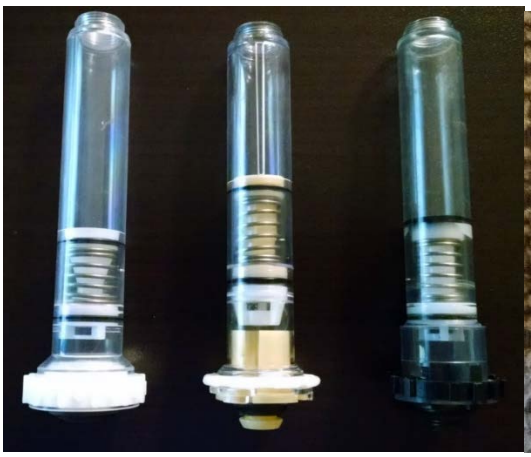
Nozzles have preferred operating pressures that affect droplet size and area of distribution—typically about 30 psi for fixed spray nozzles and 40-45 psi for nozzles that have moving or rotating stream or streams of water. Many spray sprinklers are operated at pressures that exceed the requirement for best water distribution and droplet formation through the nozzle.

In addition to pressure regulation, an additional feature for reducing water waste is the use of internal check valves to prevent low-head drainage. Typically most check valves will hold against about 10 feet of head or elevation change. By keeping water within the pipes, means less water to refill the pipes before the sprinklers will pop up and spray water. This becomes significant when best practice is to utilize multiple cycle starts with time in between to allow for water to soak into the soil.

For pressure regulation devices to work, there needs to be a pressure differential, i.e. the incoming pressure must exceed the desired regulated pressure. While this is not defined in manufacturer literature it is about 5-7 psi more than the declared pressure regulation based on field tests. In easy terms, the pressure at the base of the sprinkler needs to exceed the regulated pressure by 10 psi to have measureable results. Likewise for water savings using check valves, there needs to be an elevation change within the piping network. If the sprinkler zone area is flat, using check valves will not offer any great advantage. Therefore the potential water/energy savings from using these technologies is very site specific.

In addition to pressure regulation occurring in the sprinkler body, pressure regulation can be an added feature to control valves and/or at the point of connection. For larger systems, it is not unusual that pressure regulation is utilized at the point of connection, the zone control valve and in the sprinkler itself.

The photographs show clear models from three different manufacturers with both pressure regulators and check valves.



Overview

The improper application of water to the landscape provides an opportunity to use existing technology for spray sprinkler bodies that can reduce flow through the nozzles by using pressure regulating devices when sprinklers are over-pressurized and check valves to prevent or minimize low-head drainage. Reducing water application to the landscape without sacrificing plant health, function and aesthetic appearance benefits water providers and also reduces the use of energy for the treatment and conveyance of water to the end-user.

Table 1: Summary of Proposal

Topic	Description
Description of Standards Proposal/Framework of Roadmap	Testing of landscape irrigation sprinklers with integral pressure regulating and check valve features.
Technical Feasibility	Sprinklers with pressure regulating devices or check valves sprinklers have been in the market place for more than 15 years. It is an underused technology that offers lots of benefits.
Energy Savings and Demand Reduction	Potential water savings based on a conservative estimate of change over using the data provided in the CEC webinar on July.
Environmental Impacts and Benefits	Appropriate water use for well-maintained and healthy landscapes contributes to the well-being of people and communities. Reduced water use should yield reduction of energy for treatment and conveyance of water not beneficially used such as off-target application or wind drift.
Economic Analysis	There are ten irrigation manufacturers that produce spray sprinklers with pressure regulation and check valve options. Six of those companies are either headquartered in California or have major irrigation divisions located in California. In addition to the manufacturer, there are major distributors with stores located throughout the state that sell products to contractors. There are over 11,000 C-27 licensed contractors in the state that could be installing irrigation products. Additionally, there are big box stores that supply the DIY market.
Consumer Acceptance	Because of the extended drought experienced by California, consumer's behaviors and attitudes are receptive to making choices that will reduce water use. Water saving devices such as sprinklers with pressure regulation and check valves can be understood as a good thing to do. The additional features in the sprinkler will work without needing to modify human behavior.
Other Regulatory Considerations	The proposed recommendation will work in harmony with regulations such as California's Model Water Efficiency Landscape Ordinance, green building codes or voluntary green-building programs.

Methodology

The proposed testing procedure for pressure regulation and check valves in irrigation sprinkler bodies shall be a combination of previously published product standards or testing protocols.

Proposed Standards and Recommendations

Proposed Definitions

Reference the ASABE/ICC 802-2014 Landscape Irrigation Sprinkler and Emitter Standard for terms and definitions applicable to irrigation sprinklers.

Reference Terms and Definitions of the SWAT Equipment Functionality Test For Pressure Regulating Spray Head Sprinklers Version 3.0 (May 2012)

Reference Terms and Definitions of the SWAT Equipment Functionality Test for Pop-up Sprinkler Head Check Valves, Version 2.3 (June 2014)

Proposed Test Procedure

The Irrigation Association proposes using the SWAT Equipment Functionality Test for Pressure Regulating Spray Head Sprinklers Version 3.0 (May 2012) with modifications: See attached document showing the modifications.

In summary the modifications include: 1) modify the scope to include testing pressure regulating rotors, 2) elimination of the “continuous” pressure test, 3) reduction of the number of inlet pressure test points but requires a minimum of five test points, and 4) performance measurement to be based on either outlet pressure measurement or flow measurement.

For measuring the functionality of sprinkler check valves, follow SWAT Equipment Functionality Test for Pop-up Sprinkler Head Check Valves, Version 2.3 (June 2014) except reduce the number of cycles for the 5.4 endurance test from 2,500 to 500. This will reduce the cost of testing without reducing confidence in product performance.

Proposed Standard Metrics

Since SWAT reports how a product performs without a minimum performance criteria, the Irrigation Association proposes that the California Energy Commission follow the criteria established by the U.S. EPA WaterSense Draft Specification for Labeling Spray Sprinkler Bodies, Version 1.0 dated November 17, 2016 for measuring effectiveness of pressure regulation. Until the final testing specification is released, we are not prepared to comment on any proposed changes that may be included that is different than those proposed in the November, 2016 draft.

For measuring acceptable performance of check valves, follow the requirement identified in the ASABE/ICC 802-2014 standard for check valves as detailed in 303.2.2. Minimal acceptable performance is to hold 7-feet of head or elevation change.

Proposed Reporting Requirements

Manufactures shall publish in their literature that the product complies with this regulation and written performance reports shall be made upon request or performance results can be posted to the SWAT website.

Analysis of Proposal

Scope/Framework

Landscape irrigation sprinklers that offer integral pressure regulation and check valves that are customarily used in landscape irrigation by connecting to a piping network and are actuated when a valve is opened. Sprinklers that are used in golf courses, sports fields or large turf expanses such as parks and cemeteries that have a pressure requirement of 60 psi or greater are exempt,

Product Efficiency Opportunities

The greatest opportunity for improvement of irrigation efficiency is connected to design and management. Currently the assumption is that manufacturers know the proper pressure best performance and has made that information available in their product catalogs for a number of years. The preferred operating pressure is dependent upon the nozzle being used and so matching nozzles and sprinklers from a single manufacture is a best practice. The best water/energy savings comes with appropriate irrigation schedules that consider the soil-plant-water relationship.

Additional research is needed to determine the impacts of replacing only some sprinklers on a zone with models that have pressure regulating or check valve devices as compared to replacing all sprinklers on a zone. There is not enough data to know the impacts on sprinkler performance or potential water savings.

Technical Feasibility

A copy of a presentation made at a SWAT Roundtable Discussion prior to the opening of 2016 Water Smart Innovations conference by Brent Mecham is attached. In the presentation are some slides from simple tests based on nozzle flow to measure the effectiveness of the pressure regulation of various manufacturer's products. Of special interest is the fact that the pressure regulator and/or check valve did not have a negative effect on the proper flow of water for the nozzle when the inlet pressure was less or the same as the regulated pressure. The graphs indicate that pressure regulators seemed to activate at 5-7 psi above the declared pressure regulator.

Attached is a list of manufacturers and model numbers of their products with pressure regulating sprinkler bodies. Most manufacturers provide a check valve option. Most manufacturers provide these features in various pop-up height of risers. Two manufactures also make rotors with internal pressure regulation for larger landscape areas.

Statewide Energy Savings

The Irrigation Association can estimate potential water savings, but will defer to energy experts on the potential energy savings embedded in the water savings.

See attached document for example of cost effectiveness of installing pressure regulating sprinklers.

Environmental Impacts/Benefits

The Irrigation Association appreciates the value that Californians place on managed landscapes as contributing to the well-being of people and communities as well as the functional benefits that landscapes provide to generate oxygen and sequester carbon, mitigate urban heat-island effect, pollution abatement, erosion control, wildlife habitat, etc.

Impact on California's Economy

The immediate impact on the economy as viewed by the Irrigation Association can be measured in several ways.

- Manufacturing: Of the ten sprinkler products that have pressure-regulating devices and/or check valves six are either California based companies or have a major corporate irrigation division located in California.
- Distribution: Of product to contractors is typically done through distributors stores. The three largest distributors in the state combined have over 130 stores. There are likewise many smaller distributors.
- Contractors: There are 11,466 C-27 California licensed contractors according to the CSLB and it is estimated by CSLB that there may be nearly 3,000 unlicensed contractors in the C-27 category.
- Hardware stores and big box stores offer products for the DIY market.

The other impact on the economy is the reduced energy embedded in the water for conveyance and treatment and the impact that conservation has on extending the useful life of distribution systems both for energy and water.

Consumer Utility/Acceptance

Because of the severity of the drought, consumer behavior and acceptance of using water saving products has been changed. Many water utilities have been offering rebates as incentives to motivate consumers to change to water-conserving products and indirectly energy saving. The great advantage of using sprinklers with pressure regulating devices and check valves is that there is not a need to change behavior. The devices work without a heavy lift in educating the consumer to change how they are doing things currently. However, the devices don't remove the necessity of proper maintenance and reviewing sprinkler operation to assure water is being applied correctly.

Manufacturer Supply Chain Timelines

Since pressure regulating devices and check valves have been features available for a number of years, the IA believes that the timeline to get products in place is relatively short—that is less than a year. The biggest challenge is to remove existing stock on sprinklers without pressure regulation and

check valves. If there were incentives offered to manufacturers to take back existing stock and replacing it with approved products, the change would likely happen more quickly.

Other Regulatory Considerations

This proposal supports many new regulations, voluntary programs and Federal directives such as Presidential Executive Orders 13514 Federal Leadership in Environmental, Energy, and Economic Performance (10/2009) and 13693 Planning for Federal Sustainability in the Next Decade (3/2015). Landscape irrigation is discussed in both documents and federal agencies need to reduce water use in the landscape by more than 20 percent.

Conclusion

From the point of view of the Irrigation Association, since many irrigation systems historically have been connected to the potable water supply, the utilization of sprinklers that incorporate pressure regulation and/or check valves have the potential to reduce the amount of water applied in the landscape and by logical reasoning, the embedded energy in water would also be reduced. Pressure regulation and check valve have been available for many years by manufacturers, but adoption has been poor in spite of the many benefits these features provide. Improved sprinkler performance has been demonstrated when sprinklers are operating at or near optimal pressures for the types of nozzles being utilized. Proper pressure affects droplet formation, flow rate, application rate, distance of throw, susceptibility to wind drift, or off target application. Check valves help reduce drainage of the piping system through the lowest sprinkler. The typical additional cost for a sprinkler with both check valve and pressure regulation is $2.00-6.00 per sprinkler on 4-inch pop up models most commonly used for lawn irrigation. However, the installation labor is negligible since these two optional features are internal to the sprinkler body and are factory installed.

References

2016 SWAT Roundtable Presentation at Water Smart Innovations, Las Vegas, Nevada.

Appendices

Attached Documents:

Reference Terms and Definitions of the SWAT Equipment Functionality Test for Pressure Regulating Spray Head Sprinklers Version 3.0 (May 2012) showing proposed modifications

Reference Terms and Definitions of the SWAT Equipment Functionality Test for Pop-up Sprinkler Head Check Valves, Version 2.3 (June 2014)

Example Calculation of Potential Water Savings

List of Manufacturers with Pressure Regulating Sprinklers and or Check Valves

2016 SWAT Roundtable Presentation at Water Smart Innovations Conference, Las Vegas, Nevada.

Smart Water Application Technologies™ (SWAT)

Turf and Landscape Irrigation Equipment

PRESSURE REGULATING SPRAY HEAD SPRINKLERS

Equipment Functionality Test

Testing Protocol Version 3.0 (May 2012)

IA recommended revisions Sept. 2017

Formatted: Font: 14 pt, Not Bold

Developed by the

SWAT Committee
8280 Willow Oaks Corporate Drive, Suite 400
Fairfax, VA 22031
www.irrigation.org

© ~~2012~~ 2017 Irrigation Association

Changes included in this version

Revision 1.

The scope has been modified slightly so that pressure regulated rotary sprinklers can be tested following the protocol for the Step Test and Stability Test by measuring performance based on flow only.

Revision 2.

Based on in-house testing and upon investigation by the EPA WaterSense program to create a testing protocol for pressure regulated spray bodies, it has determine that the continuous test where pressure was increased incrementally to maximum operating pressure then decreased while the sprinkler was operational have been removed. The problem identified is this test introduces hysteresis and the pressure regulator won't respond correctly in the portion of the test where pressure is reduced incrementally. This particular test does not reflect how the sprinkler would be used in the field.

Revision 3.

In addition to measuring the outlet pressure, flow shall also be recorded for each inlet pressure setting. The requirements for flow measurement for the missing nozzle test shall be used for all tests. This provides an additional metric to evaluate performance.

Table of Contents

1. INTRODUCTION 5
2. SCOPE 5
3. TERMS AND DEFINITIONS 6
4. SYMBOLS AND ABBREVIATIONS 7
5. TEST SPECIMEN SELECTION 7
6. TEST METHOD 8
6.1. Testing Device 8
6.2. Location of Pressure Measurement 8
6.3. Measuring Equipment 8
6.3.1. Pressure Measurement 8
6.3.2. Flow Measurement 8
6.4. Testing Procedure 9
6.4.1. Step Test 9
6.4.2. Stability Test 11
6.4.3. Missing Nozzle Test 11
7. TEST REPORT 11
7.1. Step and Stability Tests 12

7.2. Missing Nozzle Test 12
8. REFERENCES 12
9. SCHEMATICS 13
9.1. Example Test Stand 13
9.2. Example Pressure Sensing 13
1. EXAMPLE DATA COLLECTION FORM
HALF-CIRCLE NOZZLE (LOW FLOW) OPERATION 15
4. EXAMPLE DATA COLLECTION FORM 32
MISSING NOZZLE TEST 32
6. EXAMPLE SUMMARY REPORT 34
~~1. INTRODUCTION ..... 4~~
~~2. SCOPE ..... 4~~
~~3. TERMS AND DEFINITIONS ..... 5~~
~~4. SYMBOLS AND ABBREVIATIONS ..... 6~~
~~5. TEST SPECIMEN SELECTION ..... 6~~
~~6. TEST METHOD ..... 6~~
~~6.1. Testing Device ..... 6~~
~~6.2. Location of Pressure Measurement ..... 7~~
~~6.3. Measuring Equipment ..... 7~~
~~6.3.1. Pressure Measurement ..... 7~~
~~6.3.2. Flow Measurement ..... 7~~
~~6.4. Procedure ..... 7~~
~~6.4.1. Continuous Test (Low Flow and High Flow) ..... 7~~
~~6.4.2. Step Test ..... 9~~
~~6.4.3. Stability Test ..... 9~~
~~6.4.4. Missing Nozzle Test ..... 9~~
~~7. TEST REPORT ..... 10~~
~~7.1. Continuous, Step, and Stability Tests ..... 10~~
~~7.2. Missing Nozzle Test ..... 10~~
~~8. REFERENCES ..... 10~~
~~9. SCHEMATICS ..... 11~~
~~9.1. Example Test Stand ..... 11~~
~~9.2. Example Pressure Sensing ..... 12~~
~~APPENDIX:~~
~~1. EXAMPLE DATA COLLECTION FORM~~
~~HALF-CIRCLE NOZZLE (LOW FLOW) OPERATION ..... 13~~
~~2. EXAMPLE DATA COLLECTION FORM~~
~~FULL-CIRCLE NOZZLE (HIGH FLOW) OPERATION ..... 14~~

~~3. EXAMPLE DATA COLLECTION FORM STEP TEST WITH HALF-CIRCLE NOZZLE OPERATION ..... 15~~

~~4. EXAMPLE DATA COLLECTION FORM STABILITY TEST WITH HALF-CIRCLE NOZZLE OPERATION ..... 16~~

~~5. EXAMPLE DATA COLLECTION FORM MISSING NOZZLE TEST ..... 17~~

~~6. EXAMPLE SUMMARY REPORT ..... 18~~

1. Introduction

Many irrigation systems have excessive pressure for the type of equipment that has been installed. Excessive pressure will cause higher flow rates and over-pressurization can lead to water losses and contribute to poor distribution uniformity. Fixed spray or multi-stream, multi-trajectory (MSMT) nozzles that fit spray head sprinklers (sprinklers that have non-rotating pop-up stems or turrets) are designed to operate within a specified pressure range and usually have a manufacturer suggested pressure for optimal performance. To address the potential problem of over-pressurization, several manufacturers have designed and manufactured sprinklers that regulate pressure to the nozzle over a range of inlet pressures. Pressure regulation is achieved within the internal parts of the spray head sprinkler. This protocol describes the testing procedure for pressure regulating ~~spray head~~ sprinklers.

2. Scope

The protocol described herein seeks to measure and evaluate the pressure regulating performance of pressure-regulated spray head sprinklers against the manufacture-advertised performance. ~~Spray head sprinklers included under this protocol include sprinklers with a non-rotating stem or turret, threads to accept a nozzle that retracts into the sprinkler body when not operating and has an automatically actuated pressure regulator that is integral to the sprinkler.~~ The measure of performance is based upon measured outlet flow and/or pressure (pressure in the sprinkler stem downstream of regulation and upstream of the nozzle) under various inlet pressures. In addition, the protocol is designed to evaluate the water saving potential of pressure regulating spray head sprinklers when the nozzle is missing ~~(simulating a sheared-off nozzle~~). ~~The scope of this protocol does not include rotary sprinklers; including impact style or closed-case gear-driven sprinklers that have a stem or turret that rotates.~~

Disclaimer

This protocol does not attempt to evaluate any other measure of sprinkler or nozzle performance regarding flow rates at specified pressures or application uniformity, nor does it set criteria for optimal sprinkler performance. No implication is made that

pressure regulation to the manufacture-advertised level results in optimal sprinkler performance. This protocol does not test material durability under specific stresses or environmental conditions.

3. Terms and Definitions

Accuracy – Degree of closeness of a measurement to a true value. In this protocol the accuracy is defined in terms of percent error , δ (Figliola, R. S. and Beasley, D. E. 2000. *Theory and design for mechanical measurements*, 3rd Ed., John Wiley and Sons, Inc., N.Y.:

$$\delta = \eta \times 100 \tag{1}$$

Where η is relative error:

$$\eta = \frac{|v - v_m|}{v} \tag{2}$$

and v = true (manufacturer-advertised) value and v_m is the measured value.

Data logger – A device that records data electronically and automatically from a sensor/transducer.

Manufacturer-advertised – Claimed performance, e.g., manufacturer-advertised regulated pressure of 30 psi.

Precision – A measure of repeatability of a measurement over a number of trials. In this protocol, precision is measured by the standard deviation (the inverse of precision, i.e. variability) and coefficient of variation (CV). The coefficient of variation is a measure of variability normalized by the mean:

$$CV = \frac{s}{\bar{x}} \tag{3}$$

where s and $\bar{x}$ are sample standard deviation and sample mean respectively:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (4)$$

Replicate – Experimental unit: for this protocol, an individual sprinkler

Specified test inlet pressure – The target inlet pressure, as distinguished from the actual testing pressure.

Sprinkler – Emission device with a body, internal parts and one or more nozzles to convert irrigation water pressure to high velocity water discharge through the air

Nozzle – The actual orifice(s) that water passes through
Spray head – Sprinkler with a nozzle that continuously applies water in a pattern over an area.
Rotor head – Sprinkler with a nozzle that applies water in a pattern over an area by means of one or more moving streams.

Test lot – the total sample of sprinklers obtained for potential testing

Test batch – a subsample of the test lot upon which testing will be performed

4. Symbols and Abbreviations

psig – pounds force per square inch gauge.
gpm – gallons per minutes
Note: U.S. customary units are used in this document

5. Test Specimen Selection

One dozen sprinklers of each tested sprinkler model with four-inch pop-up stems from three different manufacturer date codes shall be obtained ~~as "off-the-shelf-purchases" from authorized irrigation distributors~~ for a total of 36 samples (test lot). Three sprinklers shall be selected at random from each manufacture date code lot, for a total of nine sprinklers of the same model (test batch) to be subject to the ~~continuous and~~low-flow step test procedures. A new test batch shall be used for the high-flow step test procedures. The stability test and missing nozzle test procedures ~~will~~ shall use other

sprinklers drawn from the test lot. All sprinklers shall be conditioned at room temperature for a minimum of 12 hours and then each sprinkler shall operate for two minutes at 20 psig above manufacture's declared regulating pressure before being subjected to any testing.

6. Test Method

6.1. Testing Device

The testing device shall be constructed to supply a pressure range as indicated in manufacturer literature usually between 15.0 and 100.0 psig and flow rate of the test nozzles. Inlet pressure provided to replicate heads (either simultaneously run or replicated in another trial) shall not differ by more than +/- 1.0 psig from specified test pressure.

6.2. Location of Pressure Measurement

Pressure shall be recorded at the entrance to the sprinkler body (inlet) and at the sprinkler stem (outlet). Pressure taps shall not intrude into the tapped sections and any burrs or irregularities caused by provision of a pressure tap shall be removed. Pressure tap openings shall not exceed 1/10 of inside diameter of section tapped.

6.3. Flow Measurement

Flow measuring device shall be installed per manufacturer's specifications to minimize the influence of turbulence.

~~6.3.~~6.4. Measuring Equipment

~~6.3.1.~~6.4.1. Pressure Measurement

Pressure measuring device shall be a transducer capable of being logged with a datalogger. Accuracy (including linearity and hysteresis and repeatability) shall be within 0.50 psig in the range of inlet pressures tested. Precision resistors (0.1% tolerance) shall be used in any application (e.g. completion resistors at logger) that converts current to voltage for logging purposes. If using a multiplexer, power and ground leads from the pressure sensors are to be connected to a common power and ground source rather than routed through the independent multiplexer channel contacts, and sufficient warm-up time shall be allowed prior to querying sensors.

~~6.3.2.~~6.4.2. Flow Measurement

The flow measuring device shall be capable of being logged with a datalogger. The minimum resolution shall be 1 gallon, e.g. 1 gallon per pulse if using a reed

switch type pulse count meter. Other meter output for logging purposes may include electrical signal (mA or volts) or frequency (Hz). Meter accuracy shall be (100% +/- 1.~~5~~0%) for the range of flow measured. The water meter shall be located upstream of any pressure regulating device, at least 10 pipe diameters downstream of any valve, and at least five pipe diameters upstream of any elbow, tee or junction. ~~Minimum meter~~ Meter size shall ~~be one-inch~~accommodate the anticipated flow rates on the testing apparatus.

~~6.4.~~6.5. Testing Procedure

Each model submitted for testing will undergo four test procedures;

1.) ~~continuous test;~~low-flow step test;
2.) high-flow step test;
3.) stability test:
4.) missing nozzle test.

~~6.4.1.~~6.5.1. ~~Continuous~~ Pressure Step Test

For the ~~continuous~~ step test, ~~the~~ one test batch (nine sprinklers—three from each manufacturing date code) ~~selected will~~ shall undergo a "low flow~~" trial~~" test ~~achieved~~ by using ~~half-circle~~ spray nozzles with a flow rate of 1.50 gpm +/- 0.20 gpm. A "high flow" trial ~~will~~ shall utilize ~~three~~ a new test batch of sprinklers from the testing lot ~~with~~ using a ~~full-circle~~ nozzle with a flow rate of 3.6 gpm +/- 0.20 gpm~~.~~ Nozzles shall be those of the manufacturer of the sprinkler body being tested. The nozzles shall exclude pressure compensation devices, flow reduction or arc adjustability. Include appropriate filters/screens as per manufacturer.

Nozzle flow rate shall be determined first by being attached to a non-pressure-regulated sprinkler body and the flow rate recorded for the advertised pressure regulation. This shall be the base flow by which the pressure regulated sprinkler shall be evaluated in the low flow, high flow and stability test.

6.4.1.1 ~~Continuous~~ Low Flow Step Test

Sprinklers shall be tested with a ~~12-foot half-circle spray~~low flow nozzle including filter/screen at inlet pressures ranging from the manufacturer-advertised regulated pressure to the maximum inlet pressure declared in manufacturer operating specifications. Specified test inlet pressures shall be in ~~5.0 psig increments up to at least 20.0 psig above the advertised pressure and then in~~ 10.0 psig increments ~~at even numbers of 10~~up to the maximum manufacturer specified inlet pressure.~~.~~ For example: with sprinklers regulated to a pressure of 30.0 psig, the specified test pressures ~~would~~ shall be as follows:

- 30.0, ~~35.0~~, 40.0, ~~45.0~~, 50.0, 60.0 psig and in 10.0 psig increments thereafter up to the maximum pressure indicated in the manufacturer operating specification. A minimum of five test points shall be measured.

For sprinklers that are regulated at 45.0 psig the tests pressures would be as follows:

- 45.0, ~~50.0~~ 55.0, 60.0, 65.0, 70.0 psig and in 10.0 psig increments thereafter up to the maximum pressure indicated in the manufacturer operating specification. A minimum of five test points shall be measured.

For sprinklers specified with a maximum pressure not at an even number of 10, the maximum specified test pressure shall be the manufacturer-advertised maximum inlet pressure.

~~The test shall be run continuously throughout the pressure range, increasing pressure, then decreasing pressure to obtain the required specified test pressures, so that there will be two sets of readings per sprinkler at each pressure (inlet and outlet), except for the maximum pressure tested.~~ Inlet (test) pressures shall be measured at the sprinkler body. Inlet pressure shall be adjusted to within 1.0 psig of the specified testing pressure and stabilized prior to test initiation. Stabilization is considered achieved when three consecutive pressure readings are within +/- 1.0 psig of the specified test pressure. Upon inlet pressure stabilization, flow, inlet and outlet pressures shall be logged at 30 second intervals and the test duration shall be a minimum of three minutes to obtain six pressure sample pairs (inlet and outlet) within 1.0 psig of the specified test pressure. After each specified pressure test level, the testing apparatus shall be depressurized to atmospheric pressure and the sprinkler allowed to rest a minimum of 1 minute before initiating the next step in pressure.

6.4.1.2 ~~Continuous~~ High Flow Step Test

~~Three~~ A new test batch of nine randomly selected sprinklers ~~from the test batch used in the low flow trial in 6.4.1.1 will~~ shall then be tested with a ~~15-foot full-circle spray~~high flow nozzle ~~to evaluate how it performs with a higher flow rate~~ through the same pressure range and levels conducted in the low flow trial of 6.4.1.1.

~~6.4.2. Step Test~~

~~All nine heads in the test batch shall undergo the step test fitted with 12-foot half-circle nozzles. The step test procedure shall be conducted at the same specified test pressures as the continuous test procedure. After each specified test level trial, the testing apparatus shall be depressurized (to atmospheric pressure) and~~

~~the next trial initiated after re-pressurization and pressure stabilization as defined in 6.4.1.1. Each trial shall have minimum duration, sampling frequency and number of recorded sample pairs as in 6.4.1.1. Only one trial shall be done at each specified test pressure, i.e., there will not be a descending pressure mode as in the continuous test.~~

~~6.4.3.~~6.5.2. Stability Test

Three randomly selected sprinkler heads not previously tested shall be fitted with ~~12-foot~~low flow ~~half-circle~~ nozzles ~~will~~ to be subjected to a stability test. The test comprises a continuous run of 30 minutes at a specified test pressure of 20 psig above the manufacturer-advertised regulated pressure rating. Pressure readings shall be taken at 30 second intervals (for a total of 60 inlet/outlet pressure pairs) to evaluate how well the regulator controls pressure over a longer period of operation. ~~The test shall commence by increasing the pressure to the manufacturer-advertised maximum operating pressure, then reducing to +20.0 psig above the manufacturer-advertised regulated pressure.~~ Pressure and flow recording ~~will~~ shall be initiated after pressure stabilization (three consecutive pressure readings taken at 30 second intervals within +/- 1.0 psig of +20.0 psig above the specified test pressure).

~~6.4.4.~~6.5.3. Missing Nozzle Test

Three randomly selected pressure regulating sprinklers not previously tested and one non-pressure regulated sprinkler of the same size and make ~~both~~ all fitted with ~~12-foot~~low flow ~~half-circle~~ nozzles ~~will~~ shall be subjected to a missing nozzle test. Only one sprinkler shall be tested at a time and all sprinklers shall be located at the same position on the test stand. Pressure measurement at the inlet to the sprinkler and flow rate measurement is required. The tests shall be conducted at sprinkler inlet pressures (test pressures) equal to the manufacturer-advertised regulated pressure~~,~~ and ~~15~~ 20 psig above the manufacturer-specified regulated pressure. ~~, and 30 psig above the manufacturer-specified regulated pressure.~~ The stipulated test pressures are for conditions with the nozzle on. The test shall commence by increasing the pressure to within +/-1.0 psig of the specified test pressure and stabilizing as defined in 6.4.1.1 then removing the nozzle~~..~~. A minimum of 10 seconds shall be allowed for flow stabilization, then flow rate shall be measured by either of two methods: for pulse type output record seven pulse counts (six intervals) with time stamps having a minimum one second resolution for computation of six flow rates. For electrical signal (mA or volts) or frequency (Hz) output, record six flow rates at 10 second intervals.

7. Test Report

The test report shall include information by test as follows:

7.1. ~~Continuous,~~ Pressure Step~~,~~ and Stability Tests

For each sprinkler tested at each specified test pressure (inlet) record elapsed time, measured inlet pressure, measured outlet pressure, and accuracy of outlet pressure (percent error) for each pressure pair measurement (Appendix 1, Tables A-1 to A-4). This is referred to as a "data collection form". Mean, standard deviation, and CV of these measures will also be reported and subsequently used to calculate statistics of the summary tables. There will be one table for each specified test pressure and replicate.

For each set of replicates at a specified test pressure (inlet), record means (across reps) of: accuracy (percent error)~~, standard~~, standard deviation, and CV (coefficient of variation) of outlet pressure. One table covers the range of specified test pressures. This is referred to as a "summary table". Data for this table is forwarded from the appropriate data tables. The table shall also provide the grand means (across reps and pressures) of accuracy, standard deviation, and CV, computed with data in the body of the summary table. See Appendix, Example Summary Report Tables 1 to 5.

7.2. Missing Nozzle Test

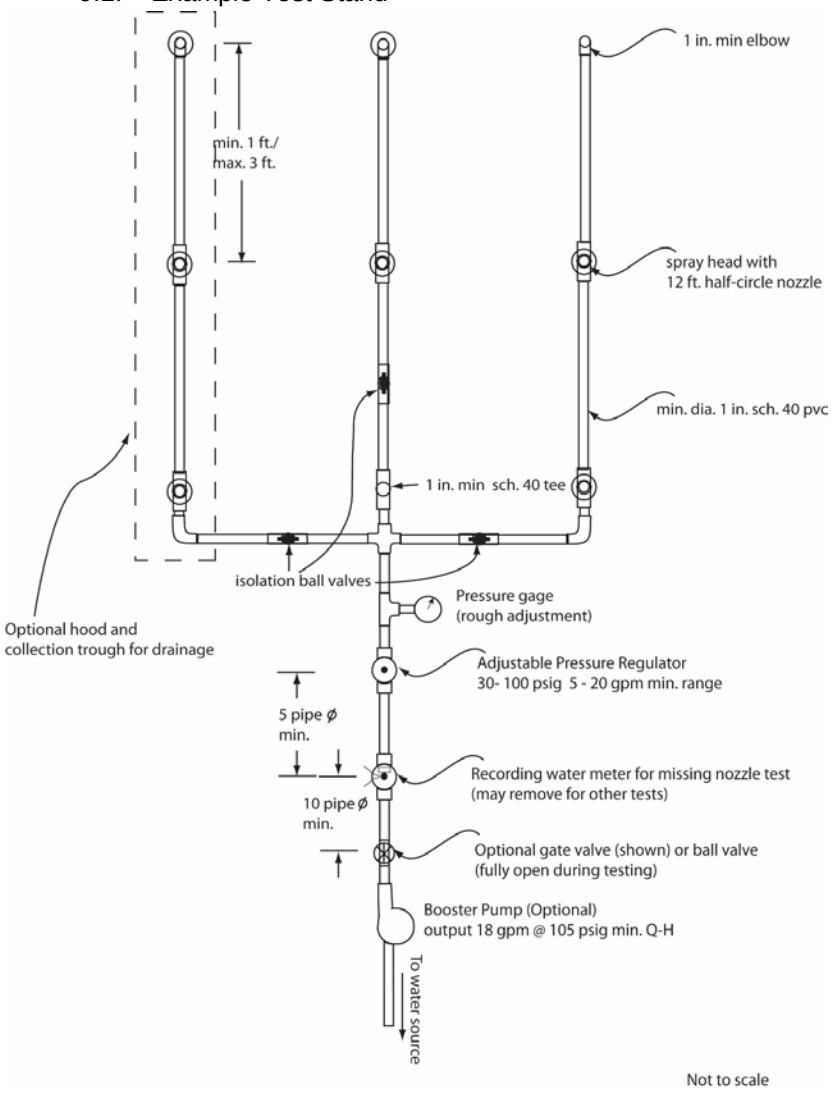
For each sprinkler head tested; record measured inlet pressure with nozzle on, elapsed time, total flow (gallons), average flow rate (gpm) over the tested period, and percent flow reduction. Record means (over regulated head reps) of elapsed time, average flow rate, and percent flow reduction for ~~each~~ the specified test inlet pressure. See Appendix, Table A-5 for an example data collection form report. Forward mean values for each specified test inlet pressure from the data collection form into a summary table that will provide grand means (across reps and pressures). See Appendix, Example Summary Report Table 5.

8. References

Figliola, R.S. and Beasley, D.E. 2000. *Theory and design for mechanical measurements*, 3rd Ed., John Wiley and Sons, Inc., N.Y.

9. Schematics

9.1. Example Test Stand



9.2. Example Pressure Sensing

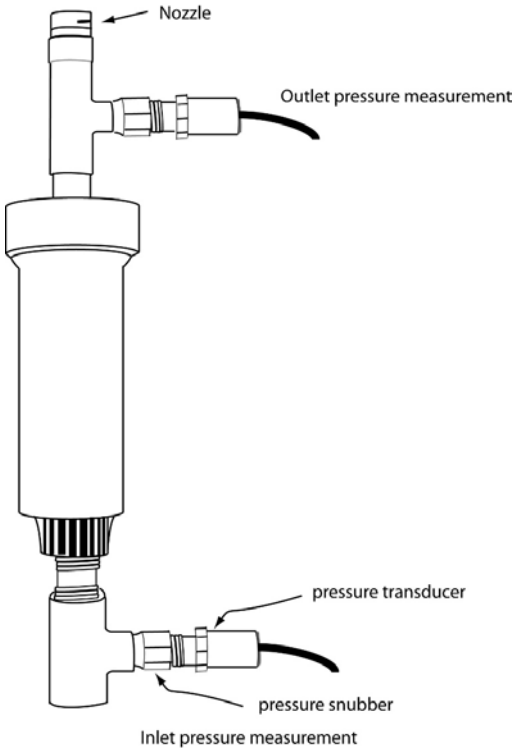

Nozzle
Outlet pressure measurement
pressure transducer
pressure snubber
Inlet pressure measurement

Table 1. Example Data Collection Form
Pressure Step Test (low flow or high flow nozzles)

Date _____ Begin Test Time _____ End Test Time _____

Sprinkler Manufacturer: _____ Sprinkler Model: _____

Advertised Regulation (psig)_____ Sprinkler ID (Rep) _____ Nozzle flow rate_____

Testing Agency_____ Technician's Name_____

Time	Measured Inlet Pressure, psig	Measured Outlet Pressure, psig	Percent Error (Outlet)	Flow Rate gpm
Mean[2]				
Std. Dev.[2]				
CV[2]				
Repeat table for each specified pressure and sprinkler up to a maximum psig, then decrease to manufacturer designated nominal psig. Minimum of 6 readings at each pressure taken at a time interval of 30 seconds				
[1] Pressure and time data collected by data logger and not manually recorded. [2] Mean, Std. Dev. and CV from each rep and pressure used in calculation of Mean, Std. Dev. and CV in subsequent summary reports.				

Table 2. Example Data Collection Form
Stability test with low flow nozzle operation

Date_____ Begin Test Time_____ End Test Time_____

Sprinkler Manufacturer:_____ Sprinkler Model:_____

Advertised Regulation (psig)_____ Sprinkler ID (Rep) _____ Nozzle flow rate_____

Testing Agency_____ Technician's Name_____

Time	Measured Inlet Pressure, psig	Measured Outlet Pressure,psig	Percent Error (Outlet)	Flow Rate gpm
Mean[2]				
Std. Dev.[2]				
CV[2]				
Repeat table for each tested sprinkler. Minimum of 6 readings at each pressure taken at a time interval of 30 seconds				
[2]Mean, Std. Dev. and CV from each replicate and pressure used in calculation of Mean, Std. Dev. and CV in subsequent summary reports				

Table 3. Example Data Collection Form
Missing Nozzle Test

Date _____ Begin Test Time _____ End Test Time _____

Sprinkler Manufacturer: _____ Sprinkler Model: _____

Advertised Regulation (psig)_____ Sprinkler ID (Rep) _____ Nozzle flow rate_____

Testing Agency_____ Technician's Name_____

Measurement No.	Measured Inlet Pressure, psig	Time or Elapsed Time, min.[1]	Flow Rate, gpm[2]
1 unregulated	Advertised + 20 psig		
2 "	"		
3 "	"		
4 "	"		
5 "	"		
6 "	"		
Mean		----------	
1 regulated	Advertised + 20 psig		
2 "	"		
3 "	"		
4 "	"		
5 "	"		
6 "	"		
Mean	"	----------	
Flow reduction, %[3]			

[1] For mAmp, voltage or frequency output record time, for pulse count output record elapsed time between pulses
[2] if pulse count output Flow rate = Volume (gal) divided by elapsed time (min)
[3] (1-(mean regulated flow rate/ mean unregulated flow rate)) *100

Note: For inlet pressures of advertised +20 psi

Table 4. Example Data Summary Report (Based on Pressure)

Low flow Step Test

Table 1. Accuracy and Precision by pressure (across replicates) and overall (across replicates and pressures).

Specified Inlet Pressure	Percent Error[1]	Standard Deviation (Std. Dev.), outlet pressure[1]	Coefficient of Variation (CV), outlet pressure)[1]
Declared			
+10 psig			
+20 psig			
+30 psig			
XX……			
Grand Mean			

[1] Calculated using Mean, Std. Dev., and CV from data collection forms

High Flow Step Test

Table 2. Accuracy and Precision by pressure (across replicates) and overall (across replicates and pressures).

Specified Inlet Pressure	Percent Error[1]	Standard Deviation (Std. Dev.), outlet pressure[1]	Coefficient of Variation (CV), outlet pressure)[1]
Declared			
+10 psig			
+20 psig			
+30 psig			
XX……			
Grand Mean			

[1] Calculated using Mean, Std. Dev., and CV from data collection forms

[1] Calculated using Mean, Std. Dev., and CV from data collection forms

Stability Test

Table 3. Accuracy and Precision by replicate (across sampling times) and overall (across replicates and sampling times).

Sprinkler ID (Rep)	Percent Error[1]	Standard Deviation (Std. Dev.), outlet pressure[1]	Coefficient of Variation (CV), outlet pressure)[1]
1			
2			
3			
Grand Mean			

[1] Calculated using Mean, Std. Dev., and CV from data collection forms

Missing Nozzle Test

Table 4. Mean flow reduction (%) by specified test inlet pressure (across replicates) and overall (across specified test inlet pressures and replicates).

Sprinkler ID (Rep)	Inlet Pressure[1]	Average Flow Rate gpm[1]	Flow Reduction %[1]
Unregulated			
Regulated + 20 psi			

[1] Calculated using means from data collection forms

Table 5. Example Data Summary Form (Based on Flow)

Step Test Low Flow Nozzle

Table 1. Pressure and flow overall (across replicates).

Specified Inlet Pressure	Unregulated Outlet Pressure psi	Regulated Outlet Pressure psi	Percent Difference Pressure	Unregulated Flow gpm	Regulated Flow gpm	Percent Difference Flow
Declared						
+10 psig						
+20 psig						
+30 psig						
+….psig						
Max. psig						
Mean						

Step Test High Flow Nozzle

Table 2. Pressure and flow overall (across replicates).

Specified Inlet Pressure	Unregulated Outlet Pressure psi	Regulated Outlet Pressure psi	Percent Difference Pressure	Unregulated Flow gpm	Regulated Flow gpm	Percent Difference Flow
Declared						
+10 psig						
+20 psig						
+30 psig						
+….psig						
Max. psig						
Mean						

Stability Test Low Flow Nozzle

Table 3. Overall across replicates

Sprinkler ID (Rep)	Average Measured Inlet Pressure psig	Average Measured Outlet Pressure psig	% Difference	Average Flow Rate	Declared Flow Rate	% Difference
1						
2						
3						
Grand Mean						

Missing Nozzle Test

Table 4. Mean flow reduction (%) by specified test inlet pressure (across replicates) and overall (across specified test inlet pressures and replicates).

Sprinkler ID (Rep)	Inlet Pressure[1]	Average Flow Rate gpm[1]	Flow Reduction %[1]
Unregulated			
Regulated + 20 psi			

[1] Calculated using means from data collection forms

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Equipment Functionality Test Protocol

Version 2.3

June 2014

SWAT Committee
8280 Willow Oaks Corporate Drive Suite 400
Fairfax, VA 22031
www.irrigation.org

©2014 Irrigation Association

Test Protocol
Smart Water Application Technologies (SWAT)™
Pop-up Sprinkler Head Check Valves

1 Scope

This testing protocol specifies the performance requirements and test methods for sprinkler head check valves, intended for operation in irrigation systems, with water at temperatures not exceeding 122° F (50° C), which may contain fertilizers and other chemicals of the types and concentrations used in irrigation systems.

The testing protocol applies to spring-loaded, hydraulically-operated valves of ½ NPT size or greater which are designed for fully open and fully closed operation. The system pressure to achieve the fully open position is determined by selection of valve internal components and may be adjustable. The valve components are integral to the sprinkler head body. This protocol does not apply to valve-in-head sprinklers.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

ANSI/ASME B1.20.1-1983 (R1992). Pipe Threads, General purpose

3 Terms and definitions

For purposes of this document, the following apply:

3.1 Check valve

Valve which automatically opens by fluid flow in a defined direction and which automatically closes to prevent fluid flow in the reverse direction

3.2 Leak-tight

No visible weeping or formation of drops or bubbles

3.3 Pop-up sprinkler

Sprinkler designed for installation so that the sprinkler nozzle is at or below ground level when it is not pressurized and above ground level when it is pressurized

3.4 Pop-up/pop-down mechanism

Mechanism within the sprinkler that automatically raises the nozzle height to improve crop clearance when the system is pressurized and automatically lowers the nozzle to the original position when the system is de-pressurized

3.5 Operating element

Component of the device by which the mechanical power is introduced

3.6 Nominal pressure

Convenient numerical designation for, and the approximate equivalent of, the maximum pressure that a check valve will operate at a test water temperature specified by the manufacturer, typically 72° F (22.2° C)

NOTE: Definition is included to help clarify a commonly misapplied concept in discussions of valve technology.

3.7 Set pressure

The inlet pressure (feet of head or elevation) that causes the sprinkler to completely pop up

3.8 Cracking pressure

The pressure (feet of head or elevation) at which the check valve starts to leak

4 Design Requirements

4.1 Materials

4.1.1 Components

Valve parts that are in contact with water shall be of non-toxic materials and resistant to fertilizers and other chemicals of the types and concentrations used in turf and agricultural irrigation. Valves shall be designed for service temperatures from 32° F (0° C) to 122° F (50° C).

4.1.2 Elastomers

Elastomers shall be selected as suitable for the application. They shall possess good sealing qualities and be resistant to deterioration by water and water-born fertilizers and chemicals.

4.2 Pressures

The nominal pressure rating and test pressure rating must be the same.

4.3 End connections

Pop-up sprinkler inlet connections incorporate ANSI/ASME B1.20.1-1983 (R1992) Tapered Pipe Threads.

4.4 Maximum water velocity

Valves shall be designed for maximum water flow velocities of 15 fps (see Note) in steady flow conditions.

NOTE: To verify that this velocity requirement has been met, calculate the velocity using the actual cross sectional area of the valve inlet and the maximum rated flow rate of the assembly as declared by the manufacturer.

5 Performance requirements

NOTE: All performance testing to be conducted in a lab with room and water temperatures of 72° F ± 4° F (22.2° C ± 2° C). Water to be filtered through a 200-mesh screen.

5.1 Mechanical strength

5.1.1 Resistance to internal pressure of all pressure-containing components (see Annex D)

The check valve and all internal components shall withstand without visible damage an internal pressure of 1.5 times the maximum allowable operating pressure as declared by the manufacturer.

5.2 Pressure loss (see Annex E)

The pressure loss measured at the full open position and a particular flow rate shall not exceed the pressure loss declared by the manufacturer at that same flow rate by more than 5%. If no pressure loss is declared, the measured pressure loss is noted in the performance report.

5.3 Water tightness

5.3.1 Short term seat tightness (see Annex A)

The seat of sprinkler head check valves in the fully closed position shall be leak-tight when subjected to an inlet pressure of 75% of the manufacturer's declared cracking pressure when tested in both the vertical and non-vertical orientation. Leak-tight is interpreted to mean no visible weeping or formation of drops at the bleed hole (shown in Figure 1) after subjecting the valve to pressure for a period of 1.0 hours.

5.3.2 Cracking and set pressure

Sprinkler head check valve shall be tested for cracking and set pressure in accordance with the test procedure given in Annex A.

Check valves shall have a cracking pressure within ±10% of the manufacturer's specified value.

5.3.3 Long-term seat tightness

Sprinkler head check valve shall be tested for long-term seat tightness in accordance with the test procedure given in Annex B.

Sprinkler head check valve shall retain a minimum of 50% of the test pressure set in accordance with Annex B.

5.4 Endurance test

Sprinkler head check valve shall keep its functional capability after being subjected to 2,500 cycles of operation in accordance with Annex C.

In order to verify these requirements, the valve shall pass the water tightness tests in accordance with 5.3.1, 5.3.2 and 5.3.3 following the test.

Dismantle the valve and check visually for failure of any valve components. Failure is defined as fractures or changes in geometric configuration.

6 Conformity assessment

6.1 General

The conformity of products to the relevant part of this test protocol shall be demonstrated by:

- Carrying out all the tests specified to ensure that all fitness for purpose criteria are met; and,
- Controlling the production process in order to ensure that the required performance levels are continuously met.

7.0 Marking

The following marks shall be compulsory

- Part identification
- Manufacturer
- Check valve or commonly used commercial equivalents e.g. “SAM” or “COM.”

8.0 Test Sample Requirements

To be listed as a SWAT tested product, the testing laboratory will obtain ten sprinklers with integral check valves from three different stores for a total of 30 units. Five samples will be randomly selected from the lot for testing. To have the results posted, all five units must comply with the manufacturer’s claims of performance.

The results will be reported for:

- Measured values compared to declared values
- Head loss through the check valve

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Annex A (Normative)

Test method for determining a pop-up sprinkler head check valve's cracking and set pressures in vertical and non-vertical orientation

Reference is made to Figure 1 and the following procedure for determining a valve's set and cracking pressures.

A.1 Mount the pop-up sprinkler head check valve to be tested at the location shown in Figure 1.

A.2 Close control valve

A.3 Connect a water supply to the flow meter inlet. Minimum sustained pressure required, 50 psi

A.4 Open control valve to provide a gauge reading of 2.0 psi

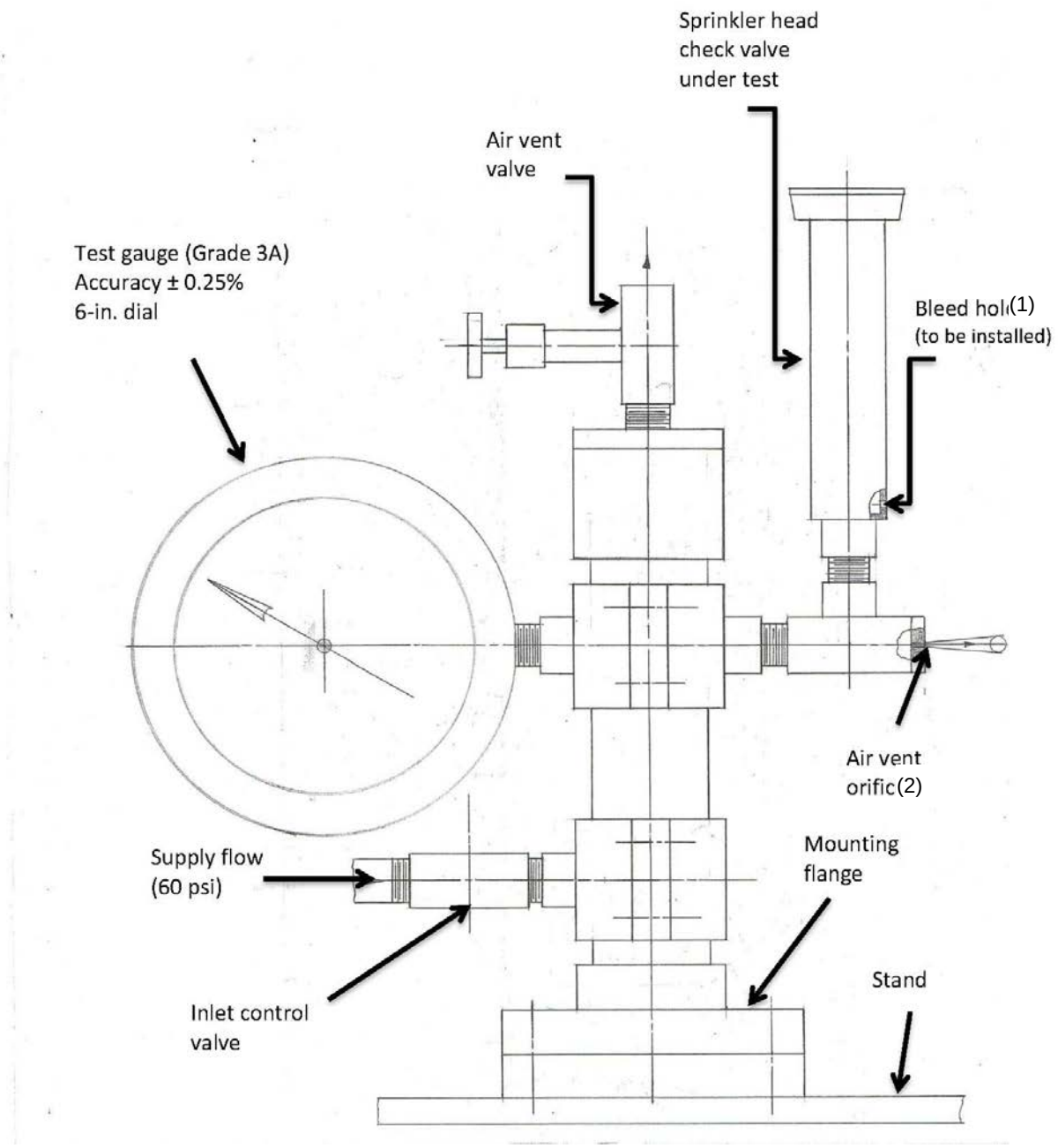
A.5 Open air bleed valve until air is evacuated; close valve

A.6 Slowly raise the water pressure until water is detected through the bleed hole. Note the pressure reading (up cracking pressure)

A.7 Continue to raise the pressure until the pop-up feature reaches the full pop-up position and note the pop-up pressure reading (set pressure)

A.8 Slowly lower the water pressure until no water is detected exiting through the bleed hole. Allow sufficient time between observations to ensure that discharge through the bleed hole is not the result of water that was stored in the sprinkler housing. Note the pop-down pressure reading (down cracking pressure)

A.9 Set the test pressure (or equivalent feet of head or elevation) at the manufacturer's published value**,** and then slowly tilt the testing apparatus axis to 15°, 30° and 45° from the vertical position and hold for two minutes at each angle. Note the angle at which leakage occurs. Reduce the pressure to zero thereby stopping the leak. Gradually raise the water supply pressure and note the value when leakage again occurs.



(1) Bleed hole, $^{1}/_{8}$ in. d
(2) Air vent orifice, $^{1}/_{32}$ in. d

Figure 1. Apparatus for pressure and leak testing of valves

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Annex B (Normative)

Test method for determining a pop-up sprinkler head check valve's long term seat tightness

B.1 General

Mount the valve on the apparatus as shown in Figure 1.

B.2 Test procedure

Pressurize the apparatus to a value of 75% of the manufacturer's declared cracking pressure. Close the control valve. Observe the pressure after a run time of 24 hours.

The valve shall remain leak-tight with no sign of weeping at the bleed hole.

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Annex C (Normative)

Test method for the endurance of the pop-up sprinkler head check valves

C.1 General

The test shall be performed with water at ambient laboratory temperature on a pop-up sprinkler head valve assembly. The test shall be able to provide water flow through the valve with a minimum velocity of 3 fps and a downstream pressure equal to 40-50 psi. A data logger is required to identify the cycle at which failure occurred.

C.2 Test procedure

The check valve to be mounted as per commercial practices. Use a cycle timer and solenoid-controlled valve with a demonstrated capability to provide a minimum “on” period of 60 seconds at 40-50 psi followed by a minimum “off” period of 60 seconds at atmospheric pressure. Subject the valve to 2,500 cycles. Remove the sprinkler head check valve and verify that the requirements of Section 5.4 have been meet.

Dismantle the check valve and check by visual inspection for failure of any valve components.

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Annex D (Normative)

Test method for determining a pop-up sprinkler head check valve's resistance to internal pressure

D.1 Replace sprinkler nozzle with a water-tight plug

D.2 After the pop-up assembly has reached its maximum extended position slowly raise the internal pressure to the value specified in paragraph 5.1.1

D.3 Retain the test pressure for 30 minutes

D.4 Release the test pressure and inspect the sprinkler head components for damage

Smart Water Application Technologies (SWAT)™

Pop-up Sprinkler Head Check Valves

Annex E (Normative)

Test method for determining a pop-up sprinkler head check valve's pressure loss

E.1 The check valve's pressure loss will be determined by comparing the inlet operating pressure reading of sprinklers with and without check valves at the same flow rate

E.2 Mount a sprinkler without a sprinkler head check valve on a standard pressure tap pipe. Set the flow rate at the midpoint of the manufacturer's design table value and read the pressure

E.3 Mount a sprinkler with a sprinkler head check valve on the pressure tap pipe. Set the same flow rate as used in E.2. Note the pressure reading and compare to the value noted in E.2

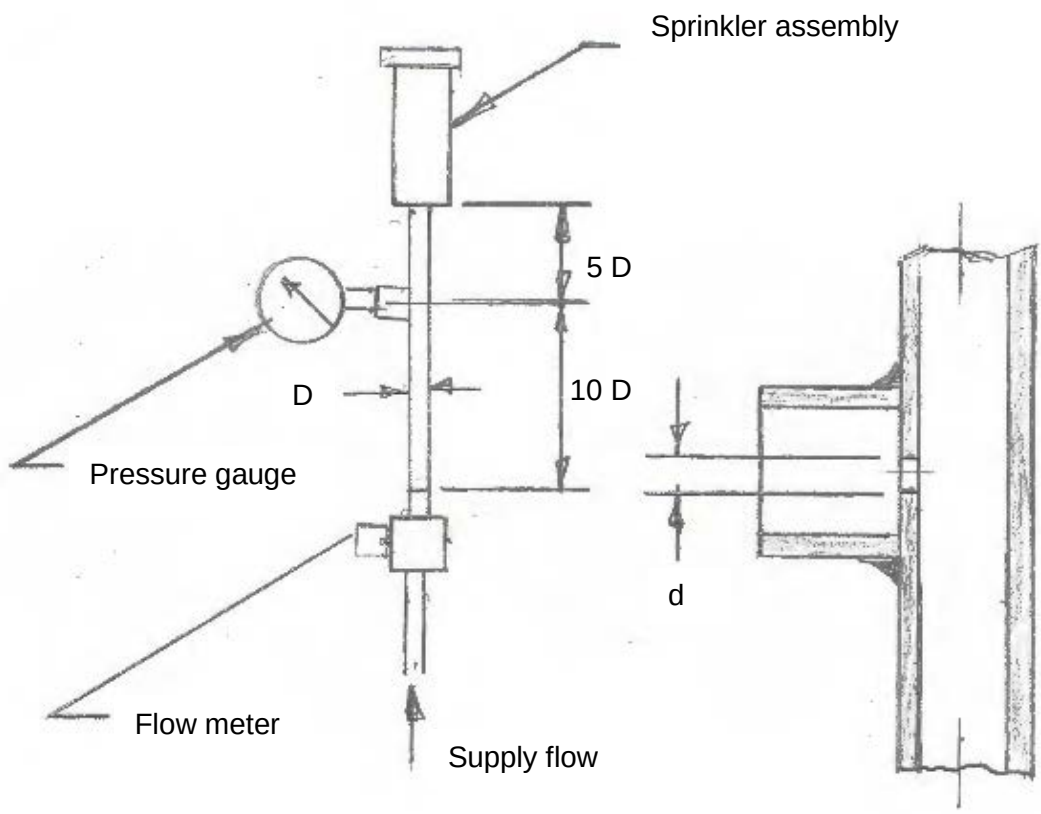


Figure 2. Pressure tap pipe. Note: D refers to pipe internal diameter; d = 1/8 in. diameter

Cost-effectiveness of Pressure Regulating Sprinklers
Brent Mecham, Industry Development Director, Irrigation Association

Background Data and Assumptions:

- From CEC Staff Estimates of SSB in California as presented in Results of Invitation to Participate Spray Sprinkler Bodies posted July 18, 2017 and explained in ITSP Webinar on August 1, 2017.
- For an average single family residential property in California there is 3,809 square feet of irrigated area with 36 sprinklers per home.

A properly designed irrigation system connected to a residential 5/8 x ¾" meter with ¾" service line should have a flow rate about 10 gpm.

10 gpm per zone and an average of 6 zones per landscape = 634.8 square feet per zone.

Using a typical precipitation rate formula PR = Q x 96.3 / Area

10gpm x 96.3 / 634.8 = 1.52 in./hr.

(This represents a typical precipitation rate of spray nozzles operating at 30 psi.)

Referencing data supplied by Ed Pike of Energy Solutions:

"The California Landscape Contractors Association and PG&E conducted a survey, at the typical water supply pressure at the irrigation system valve is about 66 psi. A couple other estimates are also summarized below.

Source	State	Measurement Point	Estimate (psi)
CLCA survey	California	Irrigation System Connection	66
WaterSense (U.S. EPA 2016b)	Multiple	Sprinkler Spray Body	60
American Water Works Association (AWWA 2016)	Multiple	Curb	76
NRDC (Lee 2017)	California	Curb	77.5

Example Calculation of Potential Water Savings:

Using the data from the CLCA survey because it represents findings of California irrigation systems measured at the irrigation system connection. 66 psi seems very realistic.

Assuming realistic pressure losses for the backflow prevention device, the irrigation control valve and piping pressure losses of 16-20 psi (about 25-30%), the available pressure at the base of the sprinkler would be 45-50 psi.

Using the Bernoulli equation, sprinklers operating at 45-50 psi instead of 30 psi results in the average flow for the zone being 12.2-12.9 gpm (22-29% above the intended flow of 10 gpm.)

Assuming an irrigation schedule of 20 minutes run time, 3 days per week for 40 weeks = 2400 minutes of run time for a year.

At 12.2 gpm = 29,280 gallons applied because of excessive pressure

At 10.0 gpm = 24,000 gallons theoretical water usage at correct pressure

= 5,280 gallons potential savings.

5,280 gallons x 6 zones = 31,680 gallons @ $5.50*/thousand = $174.24 per year of excess water cost or potential water bill savings. (*Average water rate based on draft report by Ed Pike on behalf of Statewide Codes and Standards Team)

Cost of replacing sprinklers with pressure regulating sprinklers and using an estimated useful life of 10 years.

Replace 36 sprinklers: @ additional cost of $6.00 per sprinkler	=	$ 216.00
Labor to replace = $12.00 per sprinkler	=	432.00
Total replacement cost	=	648.00

Payback for replacement sprinklers: $648.00 / $174.24 annual water savings = 3.72 years

Of course, the payback period is dependent on actual water rates and the length of the irrigation season and if spray nozzles are installed. (If rotator-type nozzles which prefer higher operating pressures are installed, then savings will be minimal, but flow rates would be much less.)

Additional savings beyond the property owner could be realized by the water utility for the impacts this would have on the water treatment plant, pumping costs or the distribution system. The real energy savings would be realized by the water utility rather than the end user.

Conclusion:

Assuming that only half of the potential market would benefit from replacing traditional sprinklers with sprinklers that incorporate pressure regulation, the greater good would still be served even though individual properties may not see a direct benefit.

There would be additional water savings with the use of check valves. There is an incremental cost in the sprinkler for this feature, but labor to install should be exactly the same.

Resources:

Several manufacturers provide documents or online calculators to help with understanding the advantages of using pressure regulating sprinklers.

K-Rain
http://www.krain.com/calculate-water-savings

Rain Bird
http://www.rainbird.com/landscape/resources/calculators/1800prs_5steps2costSavings.htm

Hunter
https://www.hunterindustries.com/sites/default/files/rc-022-br-prs-pressureregulation-web_0.pdf

Spray Head Sprinkler Bodies with Pressure Regulation and/or Check Valves

Manufacturer	Product Name	Model	Warranty years	Max. Pres. psi
HIT Products Corp	**Rain Pro 900 Series**		unknown	70
	4", 5", 6", 12" pop up heights	904-CKV-PRD		
	CKV = check valve	905-CKV-PRD		
	PRD = pressure regulator	906-CKV-PRD		
	PRD & CKV individually or	906S-CKV-PRD		
	combined	912-CKV-PRD		
Hunter Industries	**ProSpray**		5	100
	4", 6", 12" pop up heights	PROS-04-PRS30-CV		
	PRS30 = 30 psi pressure regulator	PROS-06-PRS30-CV		
	PRS40 = 40 psi pressure regulator	PROS-12-PRS30-CV		
	CV = check valve	PROS-04-PRS40-CV		
	PRS & CV combined or individually	PROS-06-PRS40-CV		
		PROS-12-PRS40-CV		
Hydro-Rain	**HRS 200**		3	90
	4", 6", 12" pop up heights	HRS-200-04-PC		
	30 psi regulator	HRS-200-04-PB		
		HRS-200-06-PC		
		HRS-200-12-PC		
Irritrol	**I-Pro Spray Heads**		5	75
	4", 6", 12" pop up heights	I-PRO 400-PR-CV		
	PR = 30 psi pressure regulator	I-PRO 600-PR-CV		
	CV= Check valve	I-PRO 1200-PR-CV		
	PR & CV individuall or combined			
K-Rain	**Pro-S Sprays**	78004-PR-CV	5	70
	4", 6", 12" pop up heights	78006-PR-CV		
	PR = 40 psi pressure regulator	78012-PR-CV		
	PR30 = 30 psi pressure regulator	78004-PR30-CV		
	CV= Check valve	78006-PR30-CV		
	pressure regulation & check valve	78012-PR30-CV		
	in combination or individually			

Orbit	**Eco-Spray**			
	30 psi no check valve	4" Press. Regulated	unknown	?
Rain Bird	**1800 Series**	1804-SAM-PRS	5	70
	4", 6", 12" pop up heights	1806-SAM-PRS		
	SAM = check valve	1812-SAM-PRS		
	PRS = pressure regulator 30 psi	1804-SAM-P45		
	P = pressure regulator 45 psi	1806-SAM-P45		
		1812-SAM-P45		
	RD1800 Series	RD-04-S-P30-F	5	100
	4", 6", 12" pop up heights	RD-04-S-P45-F		
	SAM = check valve	RD-06-S-P30-F		
	PRS = pressure regulator 30 psi	RD-06-S-P45-F		
	P = pressure regulator 45 psi	RD-12-S-P30-F		
	F = flow shield	RD-12-S-P45-F		
Signature	**63 S Series**		unknown	60
Control Systems	2-1/2", 4" 6" pop up heights	63XD-02		
	XD = pressure regulator 30 psi	63XD-04		
	w/ flow stop	63XD-06		
	XE = pressure regulator 30 psi	63XE-02		
	check valve & flow stop	63XE-04		
		63XE-06		
Toro	**570Z Series Sprays**		5	75
	4", 6", 12" pop up heights	570Z-4P-PRCOM		
	PR = pressure regulator 30 psi	570Z-6P-PRCOM		
	COM= check valve	570Z-12P-PRCOM		
	X= flow stop for missing	570Z-4P-PRXCOM		
	nozzle	570Z-6P-PRXCOM		
		570Z-12P-PRXCOM		
Weathermatic	**Pop-Up Sprayheads**		5	70
	4", 6", 12" pop up heights	LX4PRS30		
	PRS = 30 psi pressure regulator	LX6PRS30		
	CV = check valve	LX12PRS30		
		LX4PRS30-CV		
	pressure regulator & check valve	LX6PRS30-CV		
	combined or individually	LX12PRS30-CV		

Pressure Regulating Rotors

Hunter	**PGP Ultra & I-20 PRB** 4", 6" pop up height PRB = 45 psi pressure regulation includes check valve	PGP-04-PRB I-20-04-PRB I-20-06-PRB	5	100
Rain Bird	5000 Series 4", 6" 12" pop up height + = includes flow stop R= 45 psi pressure regulator SAM = check valve PC/FC part circle or full circle	5004 PC R 5004+ PC R 5004+PC(FC) SAM R 5006+ PC R 5006+PC SAM R 5012+PC SAM R	5	65

All the information supplied is from literature review on the manufacturer's websites.

Pressure Regulation for Efficient Irrigation

Brent Mecham CID, CLWM, CAIS, CIC, CLIA
Industry Development Director

Definitions

- **Pressure reduction** is reducing a high inlet pressure to a lower operating pressure depending on flow rate.
- **Pressure regulating** is maintaining a constant & lower outlet pressure at various flow rates.
- **Pressure compensation** provides a consistent flow over a range of incoming pressures.

© Irrigation Association

Why pressure regulation?

- For sprinklers helps improve droplet size and distribution of water over the area.
- Equalize pressure to emission devices in a lateral.
- Compensate for elevation changes in a zone.
- Reduced pressure = reduced flow = water saved*
- Extends useful life of components

© Irrigation Association

Pressure Regulation

© Irrigation Association

Location of Pressure Regulation

- At the point of connection
- At the zone control valve
- At the individual sprinkler

- Pressure compensation at the emission device

© Irrigation Association

Sprinkler Pressure Regulation

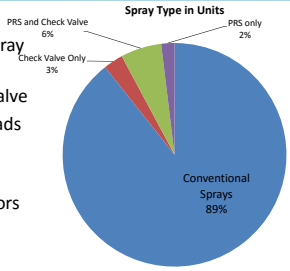
Sprinkler Pressure Regulation

- Reduce pressure = reduce flow
- ASABE/ICC 802 standard requires PR on spray heads
- MWELO references ASABE/ICC 802 standard
- SWAT testing protocol
- EPA WaterSense drafting labeling program
- California Energy Commission—Rulemaking
- Mandatory provision in many new "green codes"

© Irrigation Association

Pressure Regulating Sprinklers

- 10 manufacturers make spray bodies with PR
- Most include with check valve
- Less than 10% of spray heads sold have PR
- 2 manufacturers make rotors with PR



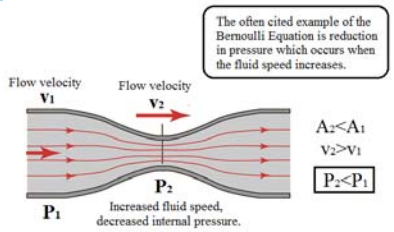
© Irrigation Association

Why Pressure Regulation

- As pressure ↑ flow ↑
- Affects
  - coverage
  - application rate
  - distribution uniformity
  - water use

© Irrigation Association

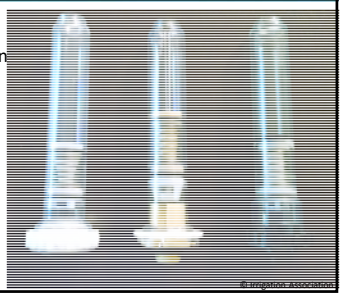
Bernoulli Equation



© Irrigation Association

Sprinkler Pressure Regulation

- Offered by manufacturers
- Relatively inexpensive option



© Irrigation Association

Adapting the Bernoulli Equation

- To estimate potential water savings or excess

$$\frac{Flow}{Flow_{PR}} = \sqrt{\frac{P}{P_{PR}}}$$

© Irrigation Association

Adapting the Bernoulli Equation

- To estimate potential water savings or excess

$$\frac{5.09}{3.60_{PR}} = \sqrt{\frac{60}{30_{PR}}}$$

$$1.414 = 1.414$$

- Flow increases 41% while pressure doubles

© Irrigation Association

Adapting the Bernoulli Equation

- Pressure increases 20%,

$$\sqrt{\frac{54}{45_{PR}}} = 1.095$$

- Flow increases @10%

© Irrigation Association

Example from catalog

Higher pressure = higher flow

Pressure psi	Nozzle Flow gpm	△ Pressure	△ Flow
20	2.85	33.3%	-20.8%
30	**3.60**	**0%**	**0%**
40	4.20	33.3%	+16.7%
50	4.58	67.7%	+27.2%
60	5.09	100%	+41.4%
70	5.50	133%	+52.8%

© Irrigation Association

Pressure vs. Performance

	30 psi	45 psi	60 psi	30 psi Tilted
DU_{LQ}	0.62	0.58	0.53	0.52
PR in/hr	1.70	1.91	2.17	1.66
Change		+12.4%	+27.6%	

Models

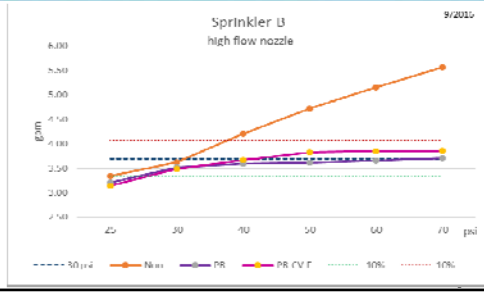
- Pressure regulation
  30 psi, 40/45 psi
- Check valve
  stop low-head drainage
- Flow reduction
  if nozzle is missing

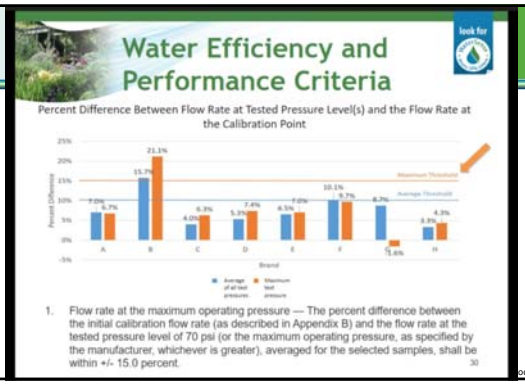
© Irrigation Association

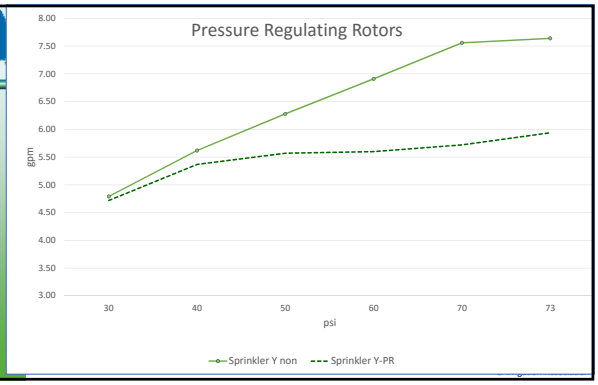
Sprinkler Pressure Regulation

© Irrigation Association

Spray Performance







Sprinkler Pressure Regulation

- Reduce high pressure to consistent lower pressure
- Equalize pressure between sprinklers
- Mitigates changes in elevation
- Optimize nozzle performance
  - Droplet size, distance of throw, rate of flow
- Control flow
- Reduce water loss if nozzle is missing

© Irrigation Association

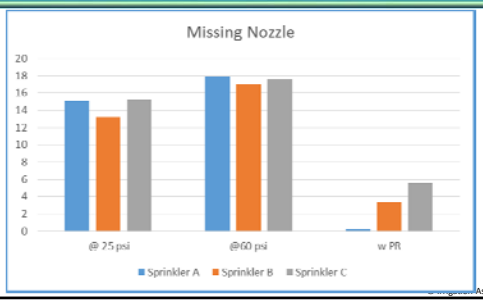
Considerations

- Pressure differential
  - 5-7 psi needed
- Use bottom inlet
- Pressure rating limitation
- Combine with valve pressure regulation
- Flushing out laterals
- Mixing PR & non PR on a zone

© Irrigation Association

Reduced Flow

Reduced flow w/ PR



© Irrigation Association

Pressure Compensation

- Nozzles
  - Compensating disc
  - screens
- Bubblers
- Drip emitters

© Irrigation Association