

SPECIAL REPORT

Vineyard Frost Protection

3 key requirements for effective protection
with overhead sprinklers

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Photo courtesy of Tablas Creek Vineyards, Paso Robles, CA

Effective vineyard frost protection depends on many factors: type of frost, severity of the frost event, crop sensitivity and risk, relative humidity and dew point, soil conditions, topography, and available resources. It also depends heavily on the equipment used in the frost protection system. Growers need to select the best frost protection method to meet the needs of their vineyards and make sure their equipment is up to the task.

This report provides information that explains three key performance requirements that should be considered when choosing equipment for optimum frost protection with overhead sprinklers.

The use of overhead sprinklers is an economical and pollution-free method for frost protection where water supply is sufficient

and weather conditions allow water to be distributed by sprinklers to the vineyard. Frost protection with sprinklers is widely used during radiation frosts that may occur on clear, calm nights, usually 24 to 48 hours after a cold front has moved through the area. Radiation frost is different than wind-borne or advection frost, which occurs when a below-freezing air mass moves through the area.

This report presents basic principles of overhead frost protection, sprinkler performance requirements, and comparisons in sprinkler design, components and materials to best meet those requirements. It will examine the three most widely used types of sprinklers for overhead frost protection: plastic hybrid impact sprinklers, plastic rotating sprinklers and brass impact sprinklers.

Using Ice and Water to Maintain 32°F

The objective of frost protection with overhead sprinklers is to maintain a temperature of 32°F at the surface of the plant. One widely used method to achieve this is to apply and maintain a thin film of water on the ice-encased surfaces of the new buds. In principle, water is constantly applied to keep the ice at 31-32°F, which keeps the buds at 32°F.

More specifically, when water is applied to the ice, a small amount of heat energy is released as the water freezes into ice. The energy required to turn liquid to solid – in this case water to ice – is called the heat of fusion. The amount of heat energy released when 32°F water is changed to 32°F ice is 144 BTUs per pound.

Continuous Ice/Water Interface Required

Effective frost protection using heat of fusion requires continual maintenance of the ice/water interface where the fusion takes place. Without a constant ice/water interface, the ice temperature can fall, actually leading to super cooling that can damage vegetation. As long as a film of water surrounds ice-coated vegetation, the temperature of the ice and vegetation cannot go below 32° F.



Photo courtesy of Tablas Creek Vineyards, Paso Robles, CA

Choosing the Right Equipment

Frost protection with overhead sprinklers is dependent upon uniformly supplying water to the ice-encased surface of the plant on regular, rapid intervals. Sprinklers must meet three key performance requirements to provide the best frost protection possible:

1. Fast and consistent rotation time
2. High uniformity
3. Reliable cold temperature operation

Plastic hybrid impact sprinklers, plastic non-impact rotating sprinklers and brass impact sprinklers are commonly used in frost protection applications. The next section of this report will consider the advantages and disadvantages of design, components and materials of each of these types of sprinklers in the three key performance requirements.

REQ 1: Fast and Consistent Rotation

Water must be applied at regular, rapid intervals to maintain the ice/water interface. It is best to select a sprinkler with a rotation time of less than 30 seconds. Not only do sprinklers need fast rotation, but rotation times need to stay consistent in cold weather and with water pressure variations.

Plastic rotating sprinklers using liquid silicone as a braking medium will slow down as the silicone thickens in cold temperatures. For this reason, hybrid or conventional impact sprinklers with a mechanical braking system using a spring and arm without a silicone medium are recommended.

Since variations in water pressure are a common condition in agricultural operations, the sprinkler needs to rotate consistently when water pressure changes. Newer plastic hybrid impact sprinklers utilize an advanced braking system design that provides consistent rotation and smooth operation during water pressure changes to maintain fast rotation and regular, rapid watering intervals.

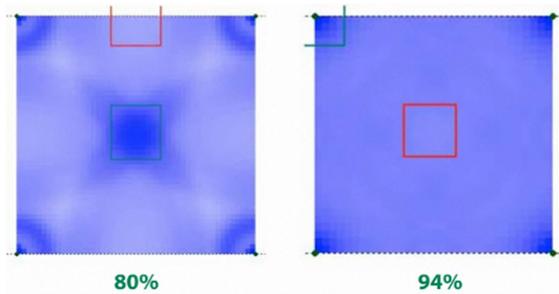
Recommended Features for Fast & Consistent Rotation	
Rotation Time	<30 seconds
Consistent Rotation with Temperature Variations	Mechanical spring and arm; avoid liquid silicone which can slow down.
Consistent Rotation with Water Pressure Variations	Brake systems designed to handle water pressure variations.



Rain Bird LF Series Sprinklers have been successfully used in temperatures as low as 17°F with virtually no reduction in rotation time.

REQ 2: High Uniformity

Water must be applied uniformly to maintain the ice/water interface on all vegetation surfaces. If some areas are left without a constant ice/water interface, the ice temperature in these areas can fall, leading to super cooling and plant damage.



Higher distribution uniformity maintains effective frost protection across the vineyard, reducing the probability of crop damage.

There are two critical factors to consider:

- **Distribution uniformity:** How evenly the sprinklers apply water across a vineyard
- **Droplet size:** Consistency of droplet size for even surface coverage

Advanced sprinkler designs provide outstanding distribution uniformity. Brass impact sprinklers use a straight bore nozzle for distribution; hybrid impact sprinklers add a deflector that shapes the water stream into a rain curtain from the riser to the end of throw. Hybrid impact sprinklers using an advanced nozzle and deflector design are recommended for higher distribution uniformity.

The water droplets need to be a consistent and optimal size to stay on the vegetation without freezing too quickly. Droplets should be large enough to resist wind and not freeze

quickly but small enough to provide even surface coverage. The advanced nozzle and deflector design of a plastic hybrid impact sprinkler provides rain curtain performance and optimal droplet size.

REQ 3: Reliable Operation in Cold

Recommended Features for High Uniformity	
<i>Distribution Uniformity</i>	Advanced nozzle and deflector design for rain curtain performance from the riser to the end of throw.
<i>Droplet Size</i>	Advanced nozzle and deflector design to produce consistent, optimal droplet size.

Temperatures

Sprinklers must be able to withstand the elements and perform reliably in cold temperatures. Sprinkler mechanisms exposed to the environment during cold weather can experience ice buildup that slows or stops operation. The spring and arm mechanism of plastic hybrid impact sprinklers are shielded from ice buildup. Springs in brass impacts are exposed and are therefore vulnerable to ice buildup and stalling.

If a sprinkler does need repair or replacement,



ACME threads reduce turns for faster removal and reinstallation during repair.

service must be completed quickly to resume operation and maintain the ice/water interface. Sprinklers that do not require tools for assembly, installation, or removal and that offer ACME threads to reduce turns are the best choice for quick repairs during frost protection applications.

High-performance plastic polymers used in hybrid impact sprinklers deliver outstanding performance and durability at a lower cost than brass impact sprinklers. Superior uniformity and lower operating pressure requirements reduce water and energy consumption. Plastic also has lower resale value, making it less vulnerable to theft than brass.

Recommended Features for Reliable Cold Temperature Operation	
<i>Freeze-resistant mechanism</i>	Spring and arm shielded from ice buildup.
<i>Reduced repair time</i>	No tools needed to assemble, install or remove sprinkler; ACME threads for fewer turns and faster removal.

Best Choice for Overhead Frost Protection

Effective vineyard frost protection with overhead sprinklers requires a uniform supply of water to the ice-encased buds on regular, rapid intervals to maintain the ice/water interface where heat of fusion occurs. To achieve this, sprinklers must deliver fast and consistent rotation in cold temperatures and with water pressure variations, high uniformity and reliable cold temperature operation.

After reviewing the sprinkler types against the three key performance requirements, plastic hybrid impact sprinklers such as the

Rain Bird® LF™ Series Sprinkler, are an excellent choice for overhead frost protection for vineyards.

Comparison Table of Sprinkler Features for Effective Overhead Frost Protection			
			
	Plastic Hybrid Impact	Plastic Rotating	Brass Impact
REQ 1: Fast & Consistent Rotation			
<i>Rotation <30 seconds*</i>	✓	✗	✓
<i>Consistent Rotation with Temperature Variations</i>	✓	✗	✓
<i>Consistent Rotation with Water Pressure Variations</i>	✓	✗	✓
REQ 2: High Uniformity			
<i>Distribution Uniformity from Rain Curtain Performance</i>	✓	✗	✗
<i>Optimal Droplet Size from Rain Curtain Performance</i>	✓	✗	✗
REQ 3: Reliable Cold Temperature Operations			
<i>Spring & Arm Shielded from Ice Buildup</i>	✓	✗	✗
<i>No Tools Required to Assemble, Install, & Remove</i>	✓	✗	✗
<i>ACME Threads for Quick On/Off</i>	✓	✓	✗

**Results derived from testing and field observations by Rain Bird Corporation*

A legacy of agricultural innovation.

Rain Bird has a rich history serving the agricultural community. Beginning in 1933 with the invention of the original horizontal action impact drive sprinkler by a Glendora, California citrus farmer (U.S. Patent #1,997,901), Rain Bird revolutionized the food production industry and ushered in a new era in irrigation, worldwide. The original impact sprinkler was designated a historic landmark in 1990 by the American Society of Agricultural Engineers.



Rain Bird has been awarded more than 130 patents for innovative irrigation products and technologies. Today, Rain Bird products are used in over 130 countries around the world to irrigate nearly every imaginable crop. Rain Bird is committed to The Intelligent Use of Water™, bringing its expertise and knowledge to further increase irrigation efficiency, minimize maintenance costs and enhance the health of crops.

Visit www.rainbird.com/ag for more information.



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