Variable Orifice Science

The secret was first discovered by a Swiss scientist over 300 years ago. His name was Daniel Bernoulli and his discovery is known as Bernoulli's Law. As Bernoulli's law of engineering applies to nozzles, it deals with the connection between pressure change and rates of flow. It works out to be this: The pressure change is much greater than the flow rate change. In fact, if the flow rate needs to double the pressure must increase four times. If the rate of flow is cut in half the pressure will be but 1/4 of where it began. So, if a spray truck speeds up from 15 mph to 30 mph, the flow rate needs to double to maintain an even application rate in GPLM as called for by the DOT manager. Therefore, the system pressure will need to increase four times. Likewise, when slowing from 30 mph to 15 mph the pressure must drop off to 1/4 of what it was at 30 mph for an even flow rate.

Most sprayer systems are built to accommodate this amount of pressure and flow change and they will work fairly well in narrow speed ranges, but in the real world of snow and storm fighting the sprayer truck driver often needs to achieve an even rate of flow across a wide range of speeds, from stopped to 60 mph or so. An operator may need to speed up from 15 mph to 60 mph; an operator may need to speed up from 5 mph to 60 mph. If the operator has a four times increase in speed (15 to 60 mph) it will require the system pressure to increase 16 times; if there is a 12 times increase in speed (5 to 60 mph) the pressure increase required for even flow will be 144 times greater to force the liquid solution through the fixed orifice nozzle. Spray systems designed for wintertime highway maintenance are simply not built for such enormous pressure ranges. And remember, to go from 1 mph to 60 mph is a 60 times change which will require a 3600 times pressure increase. The chart shown at Figure 1 shows how dramatically pressure changes with speed.

If you need	"X"	GPLM	at	1 MPH	2.5 PSI
Then you need	2 X	GPLM	at	2 MPH	10 PSI
"	4 X	GPLM	at	4 MPH	40 PSI
"	8 X	GPLM	at	8 MPH	160 PSI
"	16 X	GPLM	at	16 MPH	640 PSI
"	32 X	GPLM	at	32 MPH	2560 PSI
"	64 X	GPLM	at	64 MPH	10240 PSI

Fig. 1 Flow rate, speed and pressure for fixed orifice nozzle spraying

Anytime a fixed size discharge point is encountered, Bernoulli's Law comes into play and the way it works is that the pressure needed will change as the square of the flow rate change. So what really happens is that the typical sprayer is set up with a nozzle size adequate to operate in a mid-speed range, which varies from sprayer to sprayer. At higher speeds the flow rate will be too low and it will under-spray because the system pressure will be too low. The faster the sprayer goes the worse it gets.

If the sprayer has a ground speed override function programmed into its electronic controller, then at low speeds the sprayer will over-spray with near flooding occurring just prior to stopping. The over-spraying usually starts at approximately 15 miles per hour. If the controller does not use ground speed override, then the pressure will drop off so sharply that the necessary spraying pattern is replaced with erratic spraying, dripping and dribbling from about 10mph down to stopped. It will also fail to spray evenly until the speed returns to 10 miles per hour and above.

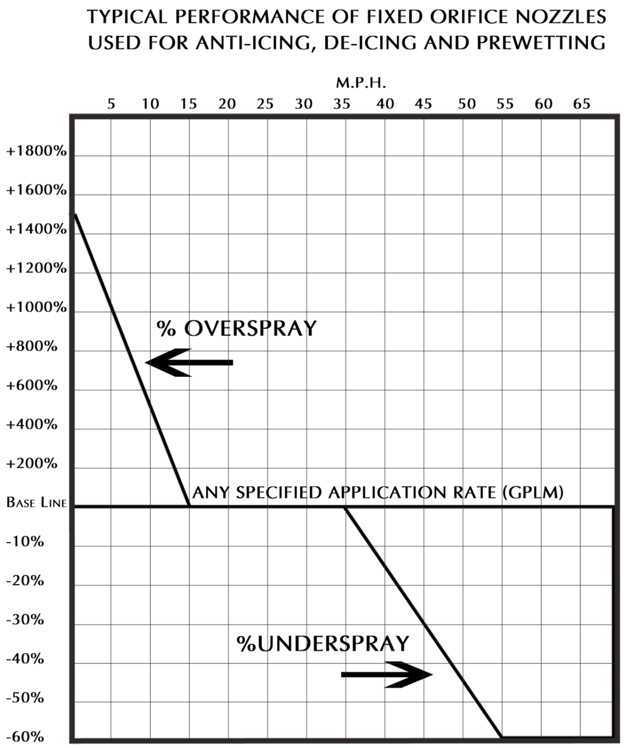

Fig. 2 Typical Performance for Fixed Nozzle Spraying

The graph shown here, Fig. 2, illustrates how sharply performance falls off outside of a limited speed range.

The variable orifice nozzle solves the restrictions encountered from the physical laws as set down by Bernoulli. The secret of the variable orifice nozzle is that it has a moveable orifice that works to increase the nozzle size opening as pressure increases. This variable orifice nozzle offers an infinite number of sizes within a range to keep operating pressures from exceeding the limits of a typical sprayer.

The cutaway drawings in fig. 3 illustrate how the variable orifice nozzle moves from a fully closed position to a fully open position. The nozzle adjusts infinitely between these two points as required by the electronic controller which determines the overall flow rate required to maintain an even GPLM spraying of the chemicals.

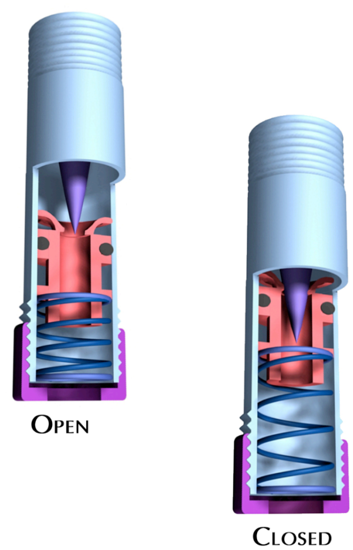

Fig. 3 Open and Closed Nozzles in Cutaway

The internal spring of the variable orifice nozzle offers the benefits of a built-in check valve. When the spring is fully extended there is no dripping and the system is designed such that when it begins to open the pressure will be sufficient to put out a uniform spray pattern across the entire roadway without any dripping or dribbling.