

# **VOLTAGE BLOCK SYSTEMS: TECHNOLOGICAL ADVANCEMENTS FOR WATERBORNE ELECTROSTATIC PAINTING**

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## Introduction

Electrostatically charging paint before it is applied to a grounded work piece is a commonly used method of improving transfer efficiency. Isolating the applied charge from ground has been a design challenge to painting equipment manufacturers since the inception of electrostatic technology. Changing from highly resistive solvent borne coatings to low resistive waterborne coatings has necessitated the development of voltage blocking technologies. These new technologies allow users of electrostatic waterborne coatings to enjoy the combined benefits of high transfer efficiency with environmental acceptability.

## Electrostatic Painting

Electrostatic charging of paint prior to application decreases paint use and the costs associated with sludge removal and disposal. As the electrically charged coating exits the spray gun, it is atomized into fine droplets. The like-charged droplets are repelled from each other and attracted to the grounded work piece or part. These phenomena together result in more uniform coverage and increased transfer efficiency.

$$\text{Transfer Efficiency} = \frac{\text{Amount of coating deposited on part}}{\text{Amount of coating atomized toward part}} \times 100\%$$

## Charging Solvent Borne Coatings

Solvent borne coatings are typically charged by placing a high-voltage probe directly in the fluid path (see Figure 1). This is known as a direct charge configuration. The electrostatic cable delivers the charge to the probe which is located at the end of the fluid resistor tip. As the coating exits the gun, it comes in contact with the fluid resistor tip and is charged. The fluid approaching the probe begins receiving a charge from the fluid downstream. As the thin stream of fluid passes over the probe it reaches its maximum charged potential, just as it exits and is atomized from the gun.

## Preventing Grounding

Each component in an electrostatic spray system is designed to prevent the voltage applied to the coating from discharging to ground. Electrostatic spray guns are equipped with nonconductive barrel extensions, fluid tips and air caps. High dielectric strength tubing and fittings carry the fluid and also act as electrostatic blocks, keeping the voltage contained within their walls. If a fluid regulator is used, it can be positioned close to the nozzle and housed in a non-conductive body.

If metallic components are used and are in the path of the charged coating, they will also become charged and act as a potential path to ground. For example, if the cup of a rotary atomizer is metallic, it will become charged by the coating and must be kept isolated from ground to prevent electrostatic discharge.

An electrostatically charged paint line is analogous to a wire. Solvent borne coatings have a high electrical resistivity, ranging from 10 to  $100 \times 10^6$  Ohm x inch. This resistivity is sufficient to block significant current from flowing up the paint line to ground. By using the definition of resistivity for a wire and Ohm's law, we can see that the resistivity of solvent borne coatings reduces the length of tubing and the distance from the ground required to ensure a low current draw on the system.

The resistance of a wire is given by:

$$R = \frac{\rho L}{A} \quad (\text{Eqn. 2})$$

Where:

- R = Resistance ( $\Omega$ )
- $\rho$  = Resistivity of wire material ( $\Omega$  in.)
- L = Length of wire (in.)
- A = Cross-sectional area of wire (in.<sup>2</sup>)

Ohm's Law States:

$$V = IR \quad (\text{Eqn. 3})$$

Where:

- V = Voltage (V)
- I = Current (A)
- R = Resistance ( $\Omega$ )

Combining Eqn. 2 and Eqn. 3 gives:

$$V = \frac{I\rho L}{A} \quad (\text{Eqn. 4})$$

Solving Eqn. 4 for length:

$$L = \frac{VA}{I\rho} \quad (\text{Eqn. 5})$$

Substituting typical solvent borne parameters into Eqn. 5:

$$V = 120,000 \text{ V}$$

The cross-sectional area of a 0.25 in. diameter hose is:

$$A = \frac{\pi (.25)^2}{4} = 0.049 \text{ in.}^2$$

Take  $\rho = 5 \times 10^7$  ( $\Omega \times \text{in.}$ )

Accept current draw of  $I = 20\mu\text{A}$

Putting these values into Eqn. 5 to find the length of tubing needed to offer sufficient resistance to the applied voltage limit current draw to  $20\mu\text{A}$ .

$$L = \frac{(120,000) (0.049)}{(5 \times 10^7) (20 \times 10^{-6})} = 5.9 \text{ in.}$$

Using the resistance of a solvent borne coating to block current from flowing upstream in a direct charge system is usually practical. All but the most conductive solvent borne coatings can be blocked by isolating several inches of tubing before a ground is introduced into the fluid stream. However, the resistivity of waterborne coatings range from 10 to 100 Ohm  $\times$  in. Putting this low resistivity into Eqn. 5 shows the need for an alternative to the natural resistance that solvent borne coatings offer.

Take  $\rho = 5 \times 10$  ( $\Omega \times \text{in.}$ )

$$L = \frac{(120,000) (0.049)}{(5 \times 10) (20 \times 10^{-6})} = 5.9 \times 10^6 \text{ in.} = 93 \text{ miles}$$

Using the resistivity of a waterborne coating to block current from flowing upstream in a direct charged system is impractical, as it would require miles of tubing. As a result, several alternatives for isolating and blocking voltage in waterborne systems have been developed. These alternatives allow users to enjoy a transfer efficiency equal to or better than solvent borne systems, while taking advantage of the benefits of environmentally safe waterborne coatings.

### The Economics of Electrostatics

The improvement in transfer efficiency achieved in using electrostatics, compared to conventional spray, will depend upon a number of variables. Spray type, (airless, HVLP, air-assisted airless, air spray or rotary atomized) geometry of the part being painted, booth airflow as well as method and magnitude of voltage applied to the coating will affect transfer efficiency.

An increase in transfer efficiency results in a decrease in the amount of coating used. The percent of coating saved with an increase in transfer efficiency is given by:

$$\% \text{ Savings} = \frac{(\text{New T.E.} - \text{Old T.E.}) \times 100\%}{\text{New T.E.}} \quad (\text{Eqn. 6})$$

This equation demonstrates that a 15 percent increase in transfer efficiency can result in more than a 15 percent savings in paint cost.

For example, if an application has a 60 percent transfer efficiency and a change to an electrostatic application raises the transfer efficiency to 75 percent, the paint savings will exceed 15 percent.

$$\% \text{ Savings} = \frac{(.75 - .6) \times 100\%}{.75} = 20\%$$

This can also be seen by approaching the problem from the flow rate required by the atomizer to achieve the desired film build. Assume the present method has a flow rate of  $300 \text{ cm}^3/\text{min.}$  and a transfer efficiency of 60 percent. If the atomizer is triggered for one minute the amount of coating atomized toward the part is  $300 \text{ cm}^3$ . From Eqn.1, the amount of coating deposited on the part is  $300 \text{ cm}^3 \times .6 = 180 \text{ cm}^3$ . A new spray process increases transfer efficiency to 75 percent. Since the amount of coating deposited on the part must remain at  $180 \text{ cm}^3$ , the amount of coating that needs to be atomized toward the part is  $180 \text{ cm}^3 / .75 = 240 \text{ cm}^3$ . So the amount of atomized coating saved is  $300 - 240 = 60 \text{ cm}^3$ . The savings is therefore  $60 / 300 \times 100\% = 20\%$ , agreeing with the result of Eqn. 6 shown above.

Figure 2 shows the percent savings that can be expected for an increase in transfer efficiency.

This figure shows only the percent savings for the amount of coating atomized. It does not include coating wasted during mixing, handling, color changing and cleaning.

The application of waterborne coatings applied without electrostatic systems can be impractical due to the unacceptably high coating consumption. The environmental benefits of applying low VOC coatings can be quickly eroded by inefficient (non-electrostatic) application.

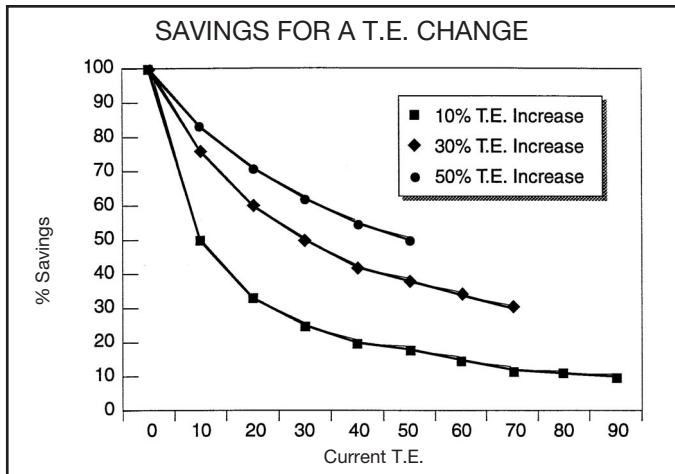


Figure 2

### Voltage Block for Waterborne Coatings

One method of charging waterborne coatings is to place high-voltage probes, out of the conductive path, around the atomizer. These probes ionize the air that the atomized particles will pass through on the way to the part. The charge that a particle is able to develop is limited to the intensity of the electrical field created by the probes as well as the time the particle spends inside the charged field. By using this indirect charging method, voltage is blocked from the conductive path to ground offered by the fluid. This allows the entire fluid delivery system to remain grounded. The disadvantages of this method include a need to frequently clean the high-voltage probes and transfer efficiency gains that are significantly less than a direct charge method offers.

The earliest method of creating a voltage block for a waterborne direct-charge system involved isolating each piece of hardware contacted by the coating. This included supply totes, pumps, filters, color change valves, hoses, regulators, dump collectors and atomizers.

This method has been used effectively with small, single color systems but becomes impractical for larger systems. For example, when an empty supply tote requires refilling, or if any component within the system requires maintenance, the entire system must be grounded until the problem is diagnosed and corrected. These types of systems also require that the isolated paint kitchen be caged, using safety interlocks to protect plant personnel from the high voltage.

An isolation breakdown can be difficult to diagnose and result in lengthy down time.

### New Voltage Block Technology

An alternative to the direct-charge, waterborne, isolated system has recently been developed. This Iso-Flo® voltage block system employs an air gap to

create a resistance similar to that which naturally exists with solvent borne coatings. This resistance also eliminates the need for isolation of system components.

A 10-inch air gap between the charged, conductive coating and the grounded supply is enough to prevent added current draw.

The Iso-Flo system uses a pneumatic cylinder to move a slider block with hydraulic couplings to the grounded supply, filling an isolated single stroke pump. After the pump is filled, the cylinder returns the slider to connect the pump to the charged atomizer (See Fig. 3). A single slider block and pump allow a fixed volume to be dispensed before the slider returns to the grounded supply to refill the pump.

The hardware in this voltage block system, including air shuttles and hydraulic couplings, can be configured in a variety of ways to meet the requirements of the end user.

In manual applications, a handgun operator typically triggers the gun for several seconds. This is typically followed by a brief pause while he is adjusting for the next area to be coated. This pause allows the slider block to move to the grounded supply and replenish the partially emptied pump. In an environment where several colors are needed, a dedicated voltage block system for each color would eliminate material and time wasted during color changing.

The Iso-Flo voltage block system can also be used for automatic painting operations. Automatic systems often require that there be no break in production. In this situation a parallel configuration can be used. A parallel configuration uses two single-stroke pumps, each with its own shuttle. Before the first pump is emptied, the second pump begins supplying the atomizers. This allows the first pump to refill and ready itself before the second pump empties.

For production lines that paint parts in batches before requiring a color change, the Iso-Flo system is available in an A-B configuration. In this situation, two parallel Iso-Flo systems are connected to a grounded color changer. While one system is supplying the atomizers, the second is flushing-out the old color and refilling with the next color needed.

Voltage block technology is continuing to advance and will soon include applications where frequent color changes currently outweigh the economic benefits of direct charging.

Efficient application is the key to the acceptance of low VOC, waterborne coatings. Continued advances in technology and process are the key to efficient application.

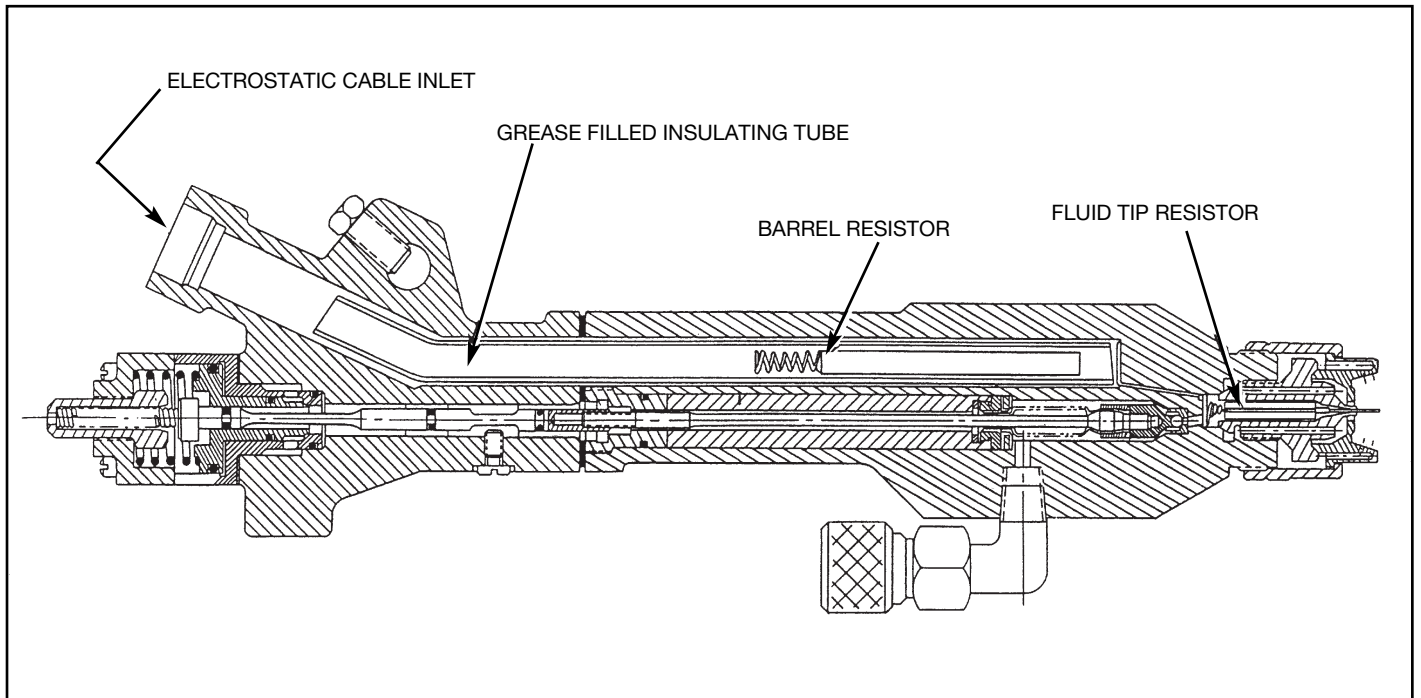


Figure 1

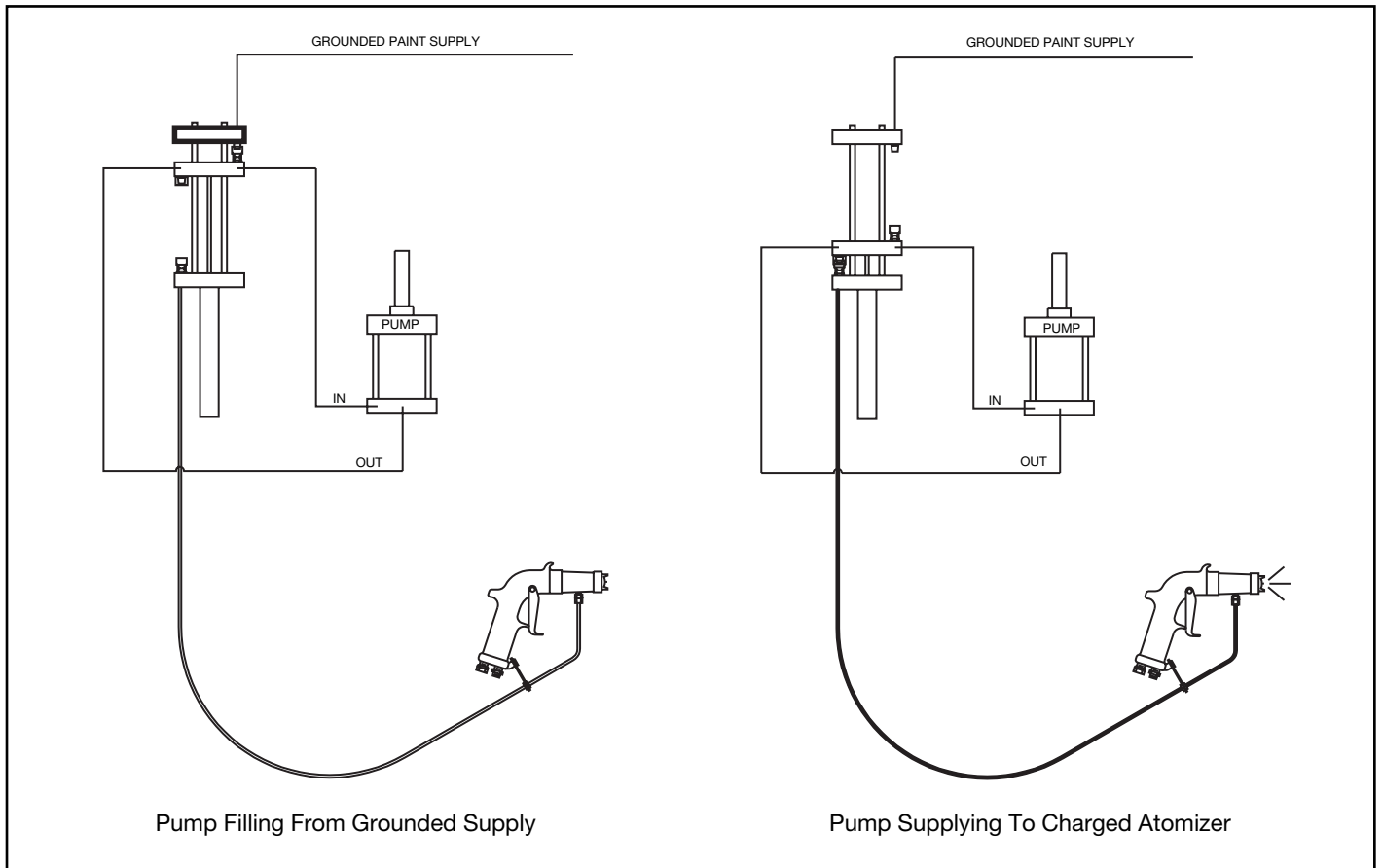


Figure 3



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