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Best Practices for Efficient and Effective Spray Rinsing: Part 2

In the September 2009 issue of *Plating & Surface Finishing*, I introduced *Best Practices* for Efficient and Effective Spray Rinsing in Part 1 of this column. Part 2 of this *Best Practices* series will discuss some of the more practical considerations of efficient and effective spray rinsing.

Effective spray rinsing requires careful specification of performance requirements. The following is a list of factors which must be considered in specifying or designing a spray rinse system.

Spray rinse performance specification

The following factors should be considered in specifying any spray rinse system.

1. Is the target (strip, rack, barrel, coil or single part) geometry complex? Does the part or parts have blind cavities? Will spray rinsing be effective and efficient? Complex geometries may require immersion rinsing or a combination of spray and immersion rinsing.
2. Will the target be stationary, moving or both?
3. Will the rinse system require a high degree of flexibility to rinse varying targets effectively and efficiently?
4. Is droplet size important? Generally, full cone nozzles produce the largest droplet size, followed by flat spray nozzles and hollow cone nozzles. Air-assisted nozzles produce finer droplets and can reduce overall water use. Small droplets have higher total surface area for a given flow rate and can improve rinsing effectiveness and efficiency through improved surface wetting and reduced droplet collisions.
5. Is high spray impact velocity important? Impact velocity is not usually necessary or even desirable for rinsing. However, high impact velocity may improve rinsing after cleaning or pickling by removing residual soils or smut formed during pickling. Impact velocity varies with spray velocity, angle and distance.
6. What flow rate is required? Flow rate for a given nozzle varies with pressure, temperature, specific gravity and viscosity. Viscosity is not normally relevant to spray rinsing. Specific gravity can be important in countercurrent spray rinsing. Temperature is not normally important in spray rinsing. Flow rate has a direct effect on droplet size. An increase in flow rate will increase the droplet size.
7. Is flow control important?
8. How will over-spray be minimized?
9. What materials of construction are required?
10. What spray pattern and manifold configuration will produce the best results?

Spray rinse configurations

Spray rinse tanks and systems can be configured in many different ways. The design of spray rinse tanks inevitably requires some compromise between flexibility, effectiveness and efficiency. **Figures 1 through 7** illustrate a few examples.

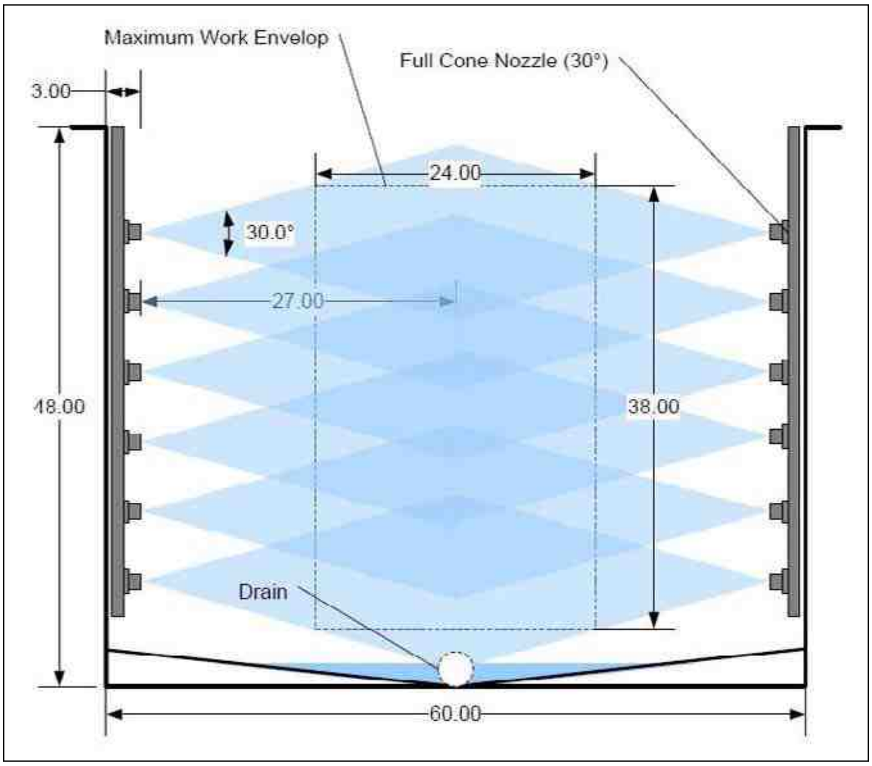

Figure 1—*Typical spray rinse tank*

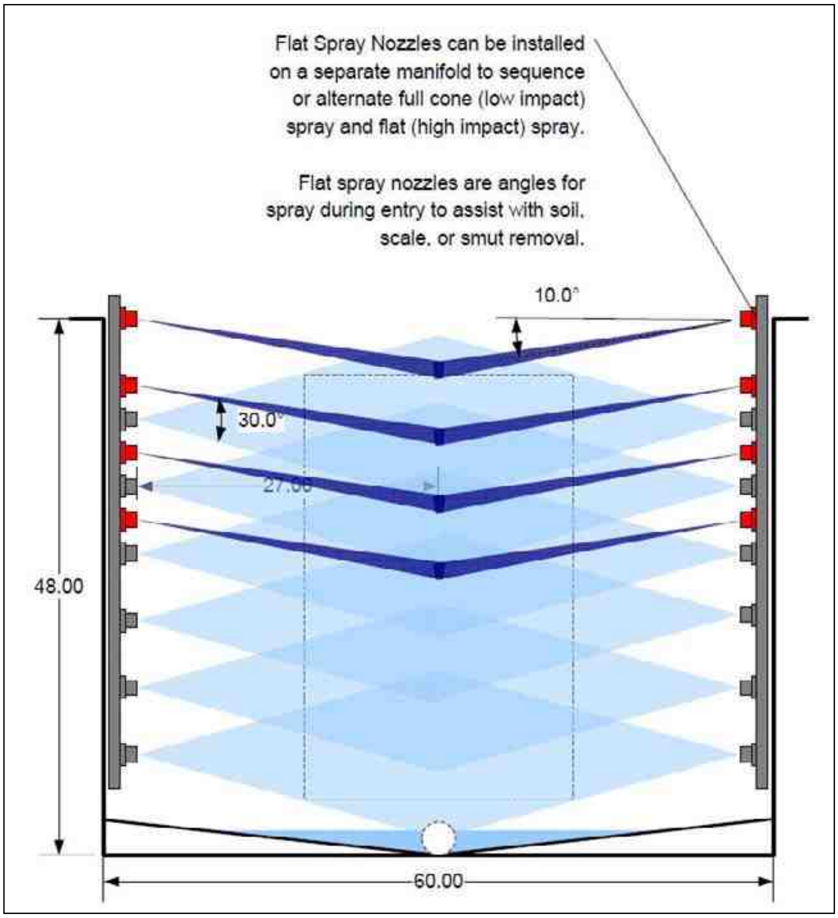

Figure 2—*Spray rinse tank with both full cone and flat spray nozzles.*

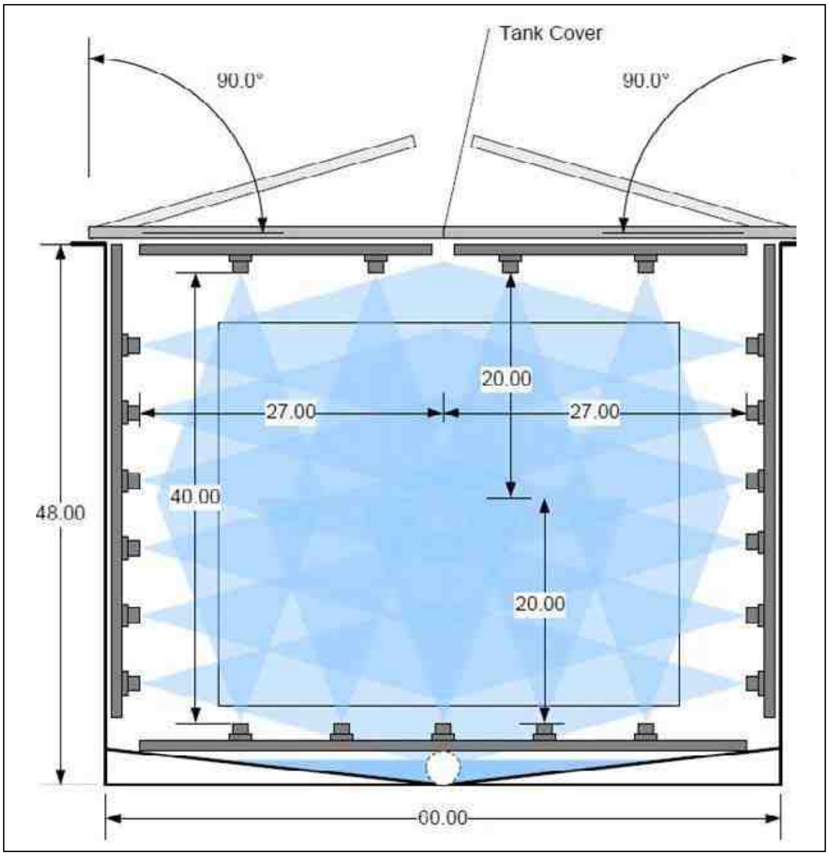

Figure 3—*Spray cabinet with side-mounted, bottom-mounted and cover-mounted nozzles.*

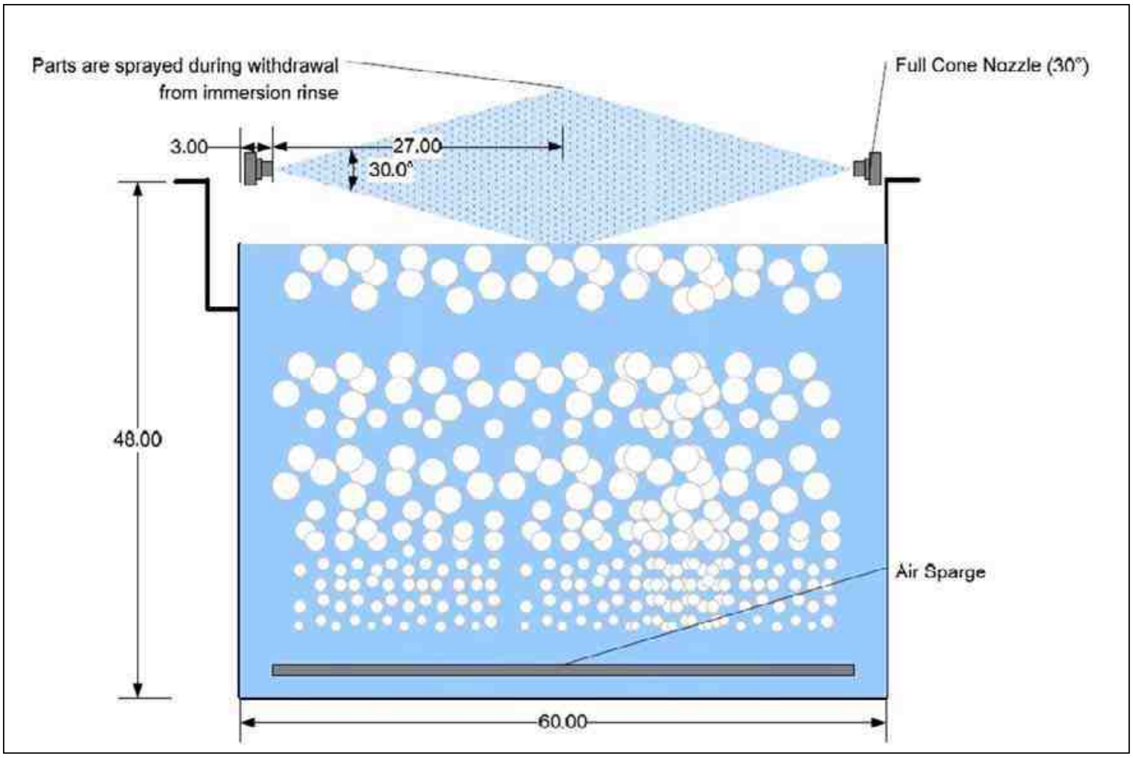

Figure 4—*Combination immersion and spray rinse tank.*

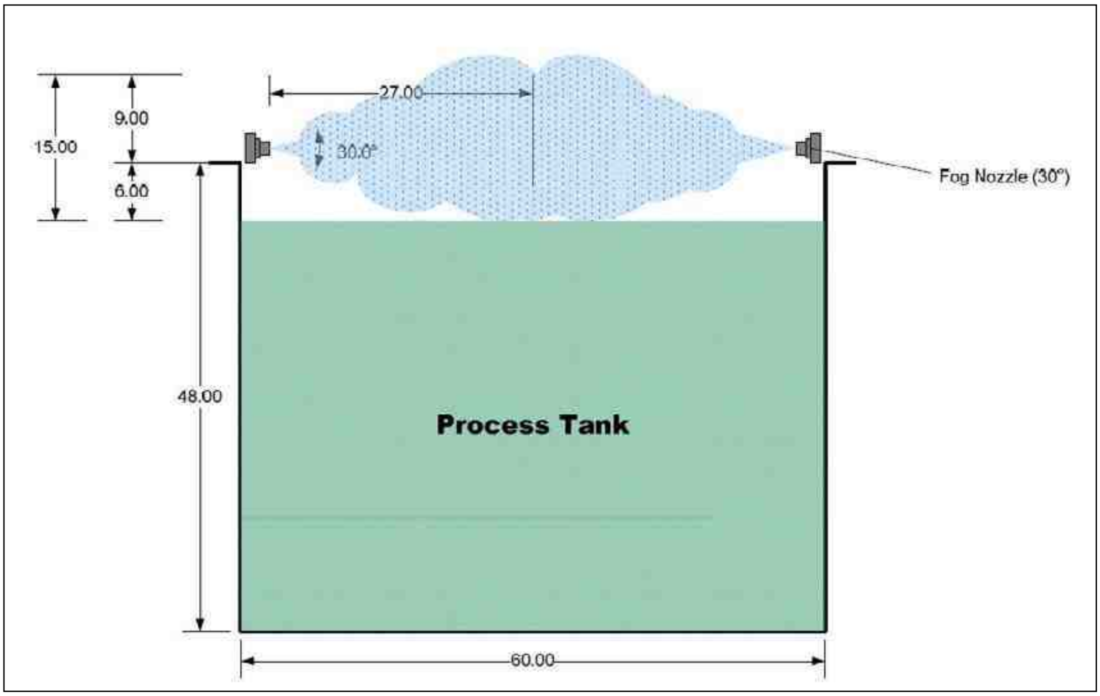

Figure 5—*Rim-mounted fog spray on process tank.* **Note:** ***Spray volume is ≤ process evaporation!***

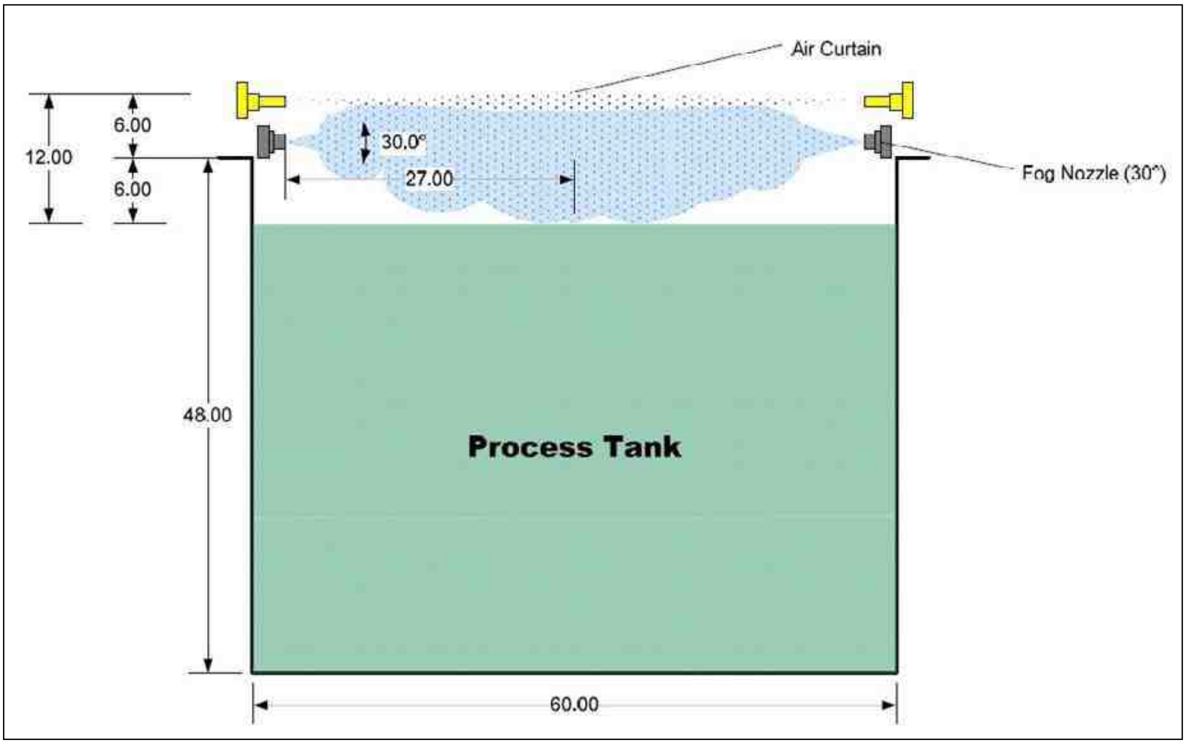

Figure 6—*Rim-mounted fog spray and air knife on process tank.*

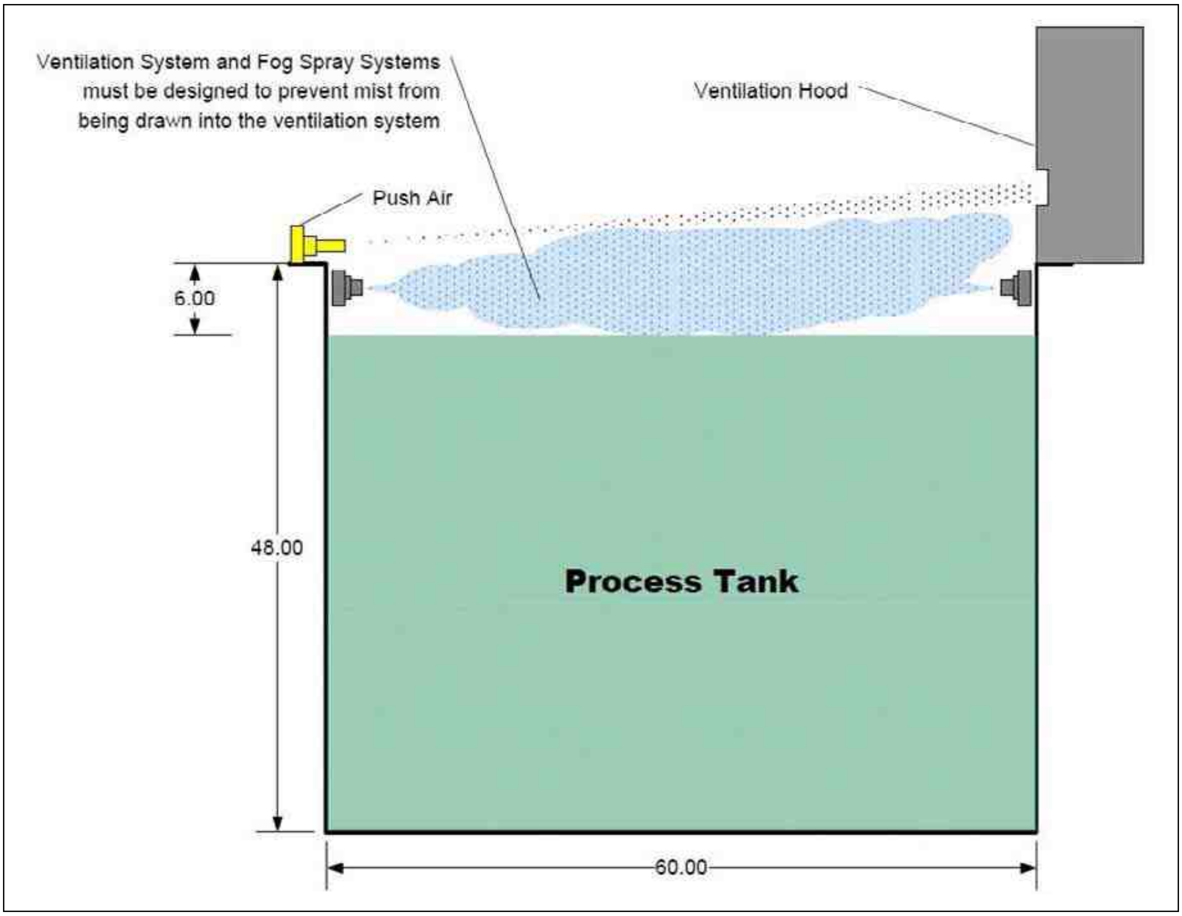

Figure 7—*Rim-mounted fog spray on process tank integrated with tank ventilation.*

Spray nozzle basics

Spray nozzles are manufactured in thousands of different types and materials. All spray nozzles are designed to produce a specific spray pattern. Spray nozzle manufacturers (including Spraying Systems, Lechler and Bete) can provide assistance in selecting the right nozzle or nozzles for a specific application. A summary of the most common types of spray nozzles follows:

Hollow cone

Hollow cone nozzles are designed for a round, "hollow" spray pattern with generally high flow rate and small drop sizes.

- Whirl chamber-type: Spray angles: 40° to 165°
- Deflected-type: Spray angles: 100° to 180°
- Spiral-type: Spray Angles: 50° to 180°

Full cone

Full cone nozzles are designed to produce a round, full spray pattern with medium-to-large sized drops and medium-to-high flow rates.

- Internal vane-type: Spray angles: 15° to 125°
- Spiral-type: Spray angles: 50° to 170°

Flat spray

Flat spray nozzles are designed to be used on a spray manifold or header for uniform, overall coverage across the impact area with medium drop sizes. Narrow spray angles provide higher impact, while the wide-angle versions produce a lower impact.

- Tapered: Spray angles: 15° to 110°
- Even: Spray angles: 25° to 65°
- Deflected type: Spray angles: 15° to 150°

Solid stream (Spray angles: 0°)

Solid stream nozzles are designed to provide the highest impact per unit area.

- Solid stream: Spray angles: 0°

Atomizing (Hydraulic)

Hydraulic atomizing nozzles are designed to provide finely atomized, low capacity spray in a hollow cone pattern without the use of compressed air.

- Fine mist: Spray angles: 35° to 165°

Atomizing (Air Assisted)

Air atomizing nozzles are designed to atomize sprays in a wide range of capacities and spray patterns, including both cone and flat spray.

Spray nozzle selection

Spray rinse design begins with a determination of the kind of spray pattern (or patterns) that will be required to rinse the variety of parts processed effectively. Common spray patterns include flat, full cone and hollow cone, as seen in **Fig. 8**.

Full cone patterns are normally best for spray rinse tanks. Flat patterns are effective for conveyorized rinsing and rim-mounted spray rinsing, where parts are moved through the spray pattern. Hollow cone patterns are not normally used in spray rinsing.

Water droplet size is also extremely important. Small droplets provide low velocity and impact force and higher contact surface area. Larger droplets have higher velocities, impact force and lower contact surface area. The angle of impingement is very important, especially at higher velocities, as the water droplets, which bounce off the surface of parts, can collide with the spray and reduce contact with the part.

Spray header design

Figures 9 through 12 illustrate proper spray manifold design.

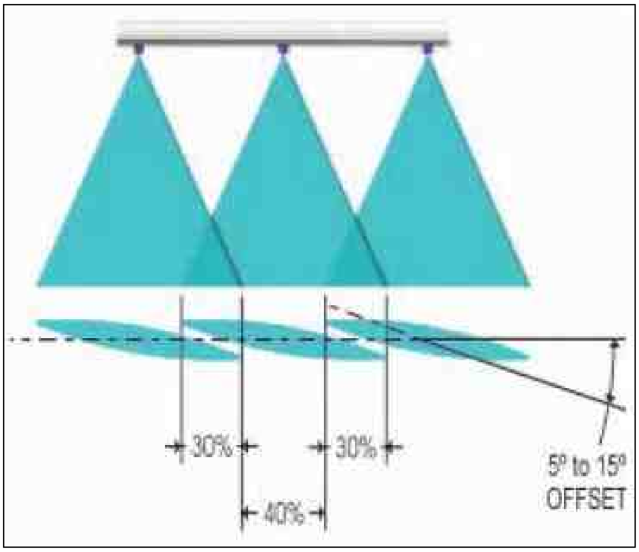

Figure 9—*Flat spray nozzle manifold illustration (Courtesy of Lechler, Inc., St. Charles, IL).*

Figure 8—*Flat, full cone and hollow cone spray nozzle pattern (Photos Courtesy of Spraying Systems Co., Farmington Hills, MI).*

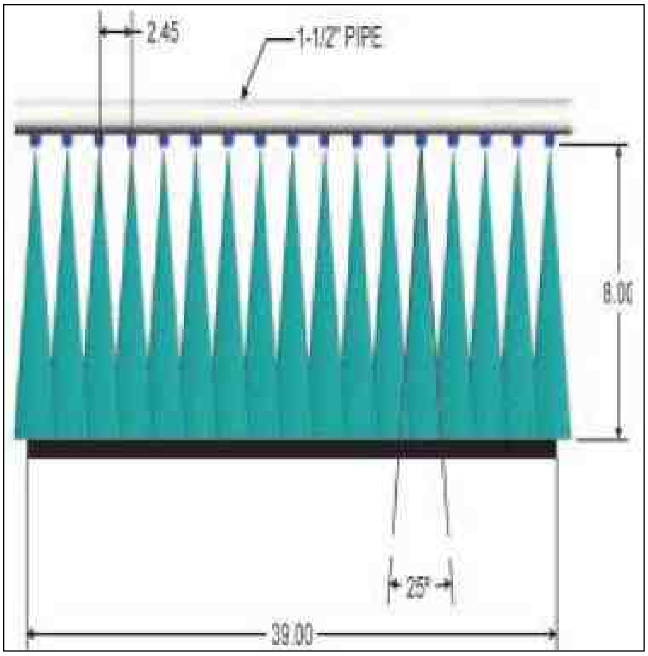

Figure 10—*Flat spray nozzle manifold illustration using a 25° spray angle (Courtesy of Lechler, Inc., St. Charles, IL).*

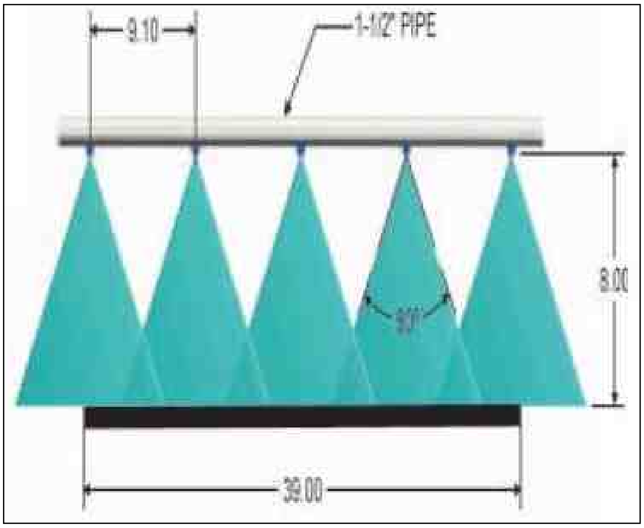

Figure 11—*Flat spray nozzle manifold illustration using an 80° spray angle (Courtesy of Lechler, Inc., St. Charles, IL).*

Ten rules for effective and efficient spray rinsing:

1. Determine the required n^{th} rinse quality requirements, establish the probable fractional spray rinse efficiency and design the spray rinse system to meet quality requirements.

2. Determine whether the rinse efficiency of spray rinsing will exceed immersion rinsing before implementing spray rinsing.

3. Use fog rinses over heated process tanks where possible to reduce net dragout load on spray and/or immersion rinsing.
   a. Model and/or measure process evaporation losses.
   b. Determine loads per hour.
   c. Spray volume load = total evaporation per hour/loads per hour

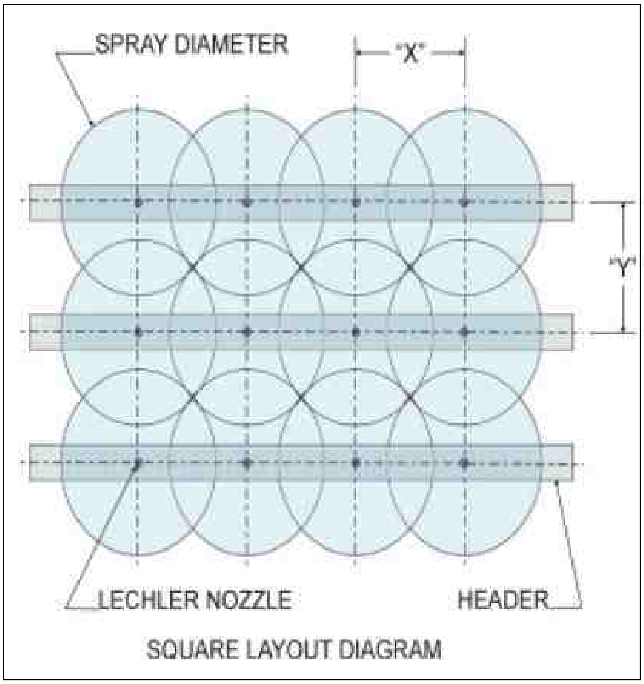

Figure 12—*Spray nozzle layout (Courtesy of Lechler, Inc., St. Charles, IL).*

4. The first rinse in a multi-stage spray rinse system may require a different design approach than subsequent rinse stages. Alternatively, a single spray tank can be configured with separate spray manifolds, which can be sequenced to simulate separate spray tanks.

5. Use a combination of immersion and spray rinsing (or immersion only rinsing) to rinse complex parts effectively.

6. Select spray nozzles for the required droplet size, spray pattern, spray distance, capacity, impact velocity and chemical compatibility.

7. Design spray manifolds and nozzle spacing for an effective spray pattern overlap. Be creative. Spray manifolds can be side-mounted, bottom-mounted, top-mounted (cover), top-mounted (flight bar), etc.

8. Utilize hand-operated spray wands to supplement spray manifolds to effectively rinse complex parts.

9. Design fog rinse manifolds and spray rinse tanks to avoid over-spraying.

10. Use deionized or softened water to feed spray rinses to avoid clogging of spray nozzles. The spray manifold feed should be equipped with strainers and/or filters.

Spray rinsing is a powerful tool for many rinsing scenarios as a supplement or replacement for immersion rinsing. However, the limitation of spray rinsing must be considered in designing efficient and effective spray rinsing. *P&SF*