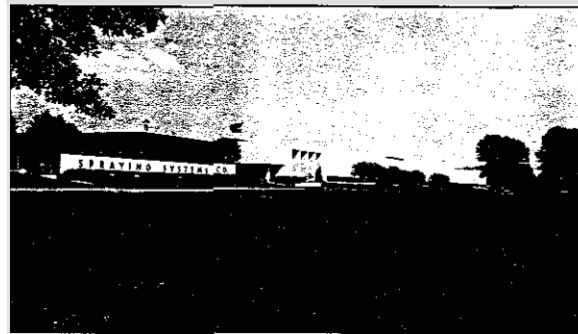


Check Your Own Spray System Cost Here:

About Spraying Systems Co.



As engineers and manufacturers of more than 18,000 sizes and styles of spray nozzles for more than 200 industries, Spraying Systems Co. knows the importance of proper nozzle selection, usage, and maintenance. Our researchers, technicians, and field sales engineers frequently see evidence of overlooked nozzle maintenance and the misapplication of nozzles and accessories. We also see the costs in material waste and poor product quality.

This Spray Nozzle Handbook is based on our applications experience, research and development work. It provides general nozzle maintenance guidelines to help you keep the costs of poor nozzle performance to a minimum. While we have not been able to include every problem, we have tried to cover the most common.

If you have any questions about nozzle specification, application, or maintenance, contact your local Spraying Systems Co. representative.

How Much is Trouble-Free Spraying Worth?

In many cases, the potential extra costs because of improper spray nozzle performance may be overlooked. We have developed some examples to show you how much improper spraying can cost. At the back of this booklet, you'll find a worksheet to help you determine your own cost exposure to an inefficient spraying situation.

If You Are Spraying Water:

| Total Spray System Flow (in GPM) | Water Wasted per Year (6,240 hours per Year*) Assuming 15% waste (gallons) | Cost of Wasted Water per Year (\$US) |
|----------------------------------|--|--------------------------------------|
| 5 | 280,800 | \$ 421 |
| 10 | 561,600 | 842 |
| 50 | 2,808,000 | 4,210 |
| 100 | 5,616,000 | 8,420 |
| 500 | 28,080,000 | 42,100 |

*6,240 hours per year is based on 24 hours per day, 5 days per week. Water/sewage cost is assumed to be \$1.50 per 1,000 gallons (3,785 liters).

Note: Aside from the dollar value of wasted water, there may be a concern related to possible water shortage problems. Wasting water could aggravate this problem.

| Total Spray System Flow (in l/min) | Water Wasted per Year (6,240 hours per Year*) Assuming 15% waste (m ³) | Cost of Wasted Water per Year (\$US) |
|------------------------------------|--|--------------------------------------|
| 20 | 1,120 | \$ 560 |
| 40 | 2,250 | 1,125 |
| 200 | 11,230 | 5,610 |
| 400 | 22,460 | 11,230 |
| 2,000 | 112,300 | 56,100 |

*6,240 hours per year is based on 24 hours per day, 5 days per week. Water/sewage cost is assumed to be US\$0.50 per m³.

Note: Aside from the dollar value of wasted water, there may be a concern related to possible water shortage problems. Wasting water could aggravate this problem.

Effect on Electrical Power Consumption:

| Total Spray System Flow (in GPM) | Excess Water Pumped per Year (6,240 hours per Year*) Assuming 15% waste (gallons) | Wasted kilowatts per Year 6,240 hours | | Cost of Energy Wasted per Year (\$.08 per kilowatt hour rate) | |
|----------------------------------|---|---------------------------------------|--------|--|----------------|
| | | 10 psi | 40 psi | 10 psi \$ (US) | 40 psi \$ (US) |
| 5 | 280,000 | 28 | 112 | \$ 2 | \$ 9 |
| 10 | 561,600 | 56 | 225 | 4 | 18 |
| 50 | 2,808,000 | 280 | 1,120 | 22 | 89 |
| 100 | 5,616,000 | 560 | 2,250 | 44 | 180 |
| 500 | 28,080,000 | 2,800 | 11,200 | 224 | 896 |
| 1,000 | 56,160,000 | 5,600 | 22,500 | 448 | 1,800 |
| | | Kilowatts at 2,000 psi | | \$ (US) at 2,000 psi | |
| 5 | 280,000 | 5,616 | | \$ 449 | |
| 10 | 561,600 | 11,230 | | 898 | |
| 50 | 2,808,000 | 56,200 | | 4,492 | |
| 100 | 5,616,000 | 112,300 | | 8,984 | |
| 500 | 28,080,000 | 562,000 | | 44,920 | |
| 1,000 | 56,160,000 | 1,123,000 | | 89,840 | |

| Total Spray System Flow (in l/min) | Excess Water Pumped per Year (6,240 hours per Year*) Assuming 15% waste (m³) | Wasted kilowatts per Year 6,240 hours | | Cost of Energy Wasted per Year (\$.08 per kilowatt hour rate) | |
|------------------------------------|--|---------------------------------------|--------|--|---------------|
| | | 1 bar | 3 bar | 1 bar \$ (US) | 3 bar \$ (US) |
| 20 | 1,120 | 43 | 129 | \$ 3 | \$ 10 |
| 40 | 2,240 | 85 | 258 | 7 | 21 |
| 200 | 11,200 | 430 | 1,290 | 34 | 104 |
| 400 | 22,400 | 850 | 2,580 | 68 | 206 |
| 2,000 | 112,000 | 4,300 | 12,900 | 340 | 1,040 |
| 4,000 | 224,000 | 8,500 | 25,800 | 680 | 2,060 |
| | | 100 bar kilowatts | | 100 bar \$ (US) | |
| 20 | 1,120 | 4,280 | | \$ 342 | |
| 40 | 2,240 | 8,560 | | 685 | |
| 200 | 11,200 | 42,800 | | 3,420 | |
| 400 | 22,400 | 85,600 | | 6,850 | |
| 2,000 | 112,000 | 428,000 | | 34,200 | |
| 4,000 | 224,000 | 856,000 | | 68,500 | |

240 hours per year is based on 24 hours per day, 5 days per week.

List the various spraying applications in your plant: (cleaning, cooling, coating, etc.)

Assign your cost of sprayed material per gallon for each application here:

\$ _____ /gallon (liter)

\$ _____ /gallon (liter)

\$ _____ /gallon (liter)

\$ _____ /gallon (liter)

\$ _____ /gallon (liter)

To isolate the potential cost for one condition:

Fill in its spray system capacity:
Convert to GPH (l/h):
How many hours per day do you spray?
How many days per week do you spray?
multiply (A) x (B) x 52 x GPH (l/h)

_____ GPM (l/min)
_____ GPH (l/h)
_____ hours per day (A)
_____ days per week (B)
_____ Gallons (Liters)
_____ per year consumed
per gallon (liter)

Enter Sprayed Liquid Cost:

\$ _____

Multiply gallons (liters) per year x Cost per gallon (liter):

_____ Material cost per year through just one spraying operation.

Multiply material cost per year x .15

_____ This represents the cost of wasted materials per year (based on an average 15 percent increase in flow rate over rated capacity).

To isolate the potential cost for one condition:

Fill in its spray system capacity:
Convert to GPH (l/h):
How many hours per day do you spray?
How many days per week do you spray?
multiply (A) x (B) x 52 x GPH (l/h)

_____ GPM (l/min)
_____ GPH (l/h)
_____ hours per day (A)
_____ days per week (B)
_____ Gallons (Liters)
_____ per year consumed
per gallon (liter)

Enter Sprayed Liquid Cost

\$ _____

Multiply gallons (liters) per year x Cost per gallon (liter):

_____ Material cost per year through just one spraying operation

Multiply material cost per year x .15

_____ This represents the cost of wasted materials per year (based on an average 15 percent increase in flow rate over rated capacity).

To isolate the potential cost for one condition:

Fill in its spray system capacity:
Convert to GPH (l/h):
How many hours per day do you spray?
How many days per week do you spray?
multiply (A) x (B) x 52 x GPH (l/h)

_____ GPM (l/min)
_____ GPH (l/h)
_____ hours per day (A)
_____ days per week (B)
_____ Gallons (Liters)
_____ per year consumed
per gallon (liter)

Enter Sprayed Liquid Cost:

\$ _____

Multiply gallons (liters) per year x Cost per gallon (liter):

_____ Material cost per year through just one spraying operation.

Multiply material cost per year x .15

_____ This represents the cost of wasted materials per year (based on an average 15 percent increase in flow rate over rated capacity).

Note: This form may be reproduced without permission to evaluate the costs of additional spraying operations

If You Are Spraying Solutions, Coatings, Solvents, Lubricants:

ment intervals. By conforming to this rigid schedule, the quality of the steel plate is maintained in accordance with pre-determined high quality standard levels. Other mills have chosen different replacement schedules to suit their own conditions.

In some applications, it may be possible to compensate temporarily for worn orifice problems by decreasing the spray nozzle pressure to deliver the original required flow rate. However, this lower pressure performance may compromise the actual spray coverage as well as the uniformity of the spray distribution, while simultaneously resulting in larger droplet sizes and possibly less impact. In such cases, the acceptance of the lower pressure operation may be a false economy, possibly costing more in product quality than new nozzle replacement costs.

While manual labor is required to remove nozzles for cleaning, inspection, and flow rate checks, this time can be reduced to a minimum by using Spraying Systems Co's, patented QuickJet® system. It should also be noted that these quick-change nozzles also provide a self-alignment feature which engages automatically as the new quick change tip is attached to the nozzle body.

This new type of nozzle eliminates the requirement for wrench tools. The removal and replacement of spray tips is quickly and simply done by hand, and no additional time is required for spray pattern alignment. A second tip can be installed in seconds and the system operation back on-line, while the used tip is inspected and cleaned.

Another important consideration at nozzle replacement time is whether the spray performance can be improved, possibly by changing to a smaller or larger capacity nozzle or to a different type of nozzle.

| Total Spray System Flow (in GPM) | Chemicals Wasted per Year (6,240 hours per Year*) | | Based On Sprayed Chemical Cost (per gallon) | Cost of Wasted Chemicals per Year \$(US) |
|----------------------------------|---|--|---|--|
| | Assuming 15% waste (gallons) | | | |
| .10 | 5,620 | | \$ 0.50 | \$ 2,810 |
| | | | 2.00 | 11,240 |
| | | | 5.00 | 28,100 |
| | | | 20.00 | 112,400 |
| .25 | 14,040 | | 0.50 | 7,020 |
| | | | 2.00 | 28,080 |
| | | | 5.00 | 70,200 |
| | | | 20.00 | 280,800 |
| 1.0 | 56,200 | | 0.50 | 28,100 |
| | | | 2.00 | 112,400 |
| | | | 5.00 | 281,000 |
| | | | 20.00 | 1,124,000 |
| 3.0 | 168,480 | | 0.50 | 84,240 |
| | | | 2.00 | 336,960 |
| | | | 5.00 | 842,400 |
| | | | 20.00 | 3,369,600 |

| Total Spray System Flow (in l/min) | Chemicals Wasted per Year (6,240 hours per Year*) | | Based On Sprayed Chemical Cost (per liter) | Cost of Wasted Chemicals per Year \$(US) |
|------------------------------------|---|--|--|--|
| | Assuming 15% waste (liters) | | | |
| .50 | 28,100 | | \$0.10 | \$ 2,810 |
| | | | 0.40 | 11,240 |
| | | | 1.00 | 28,100 |
| | | | 4.00 | 112,400 |
| 1.5 | 84,200 | | 0.10 | 8,420 |
| | | | 0.40 | 33,690 |
| | | | 1.00 | 84,200 |
| | | | 4.00 | 336,800 |
| 5.0 | 281,000 | | 0.10 | 28,100 |
| | | | 0.40 | 112,400 |
| | | | 1.00 | 281,000 |
| | | | 4.00 | 1,124,000 |
| 15.0 | 842,000 | | 0.10 | 84,200 |
| | | | 0.40 | 336,800 |
| | | | 1.00 | 842,000 |
| | | | 4.00 | 3,368,000 |

*6,240 hours per year is based on 24 hours per day, 5 days per week. There are, of course, other less tangible but potentially more expensive factors to consider when calculating the value of trouble-free spraying. They include quality control problems, customer complaints, and reduced efficiency of plant operations such as gas cooling, dust control, etc.

Spray Equipment Performance Can Affect the Production Process in Many Ways. Here Are Four Examples:



Patented QuickJet® Nozzle System speeds spray tip maintenance in multi-stage auto body washing and coating operation.

Problem: Excessive maintenance time required to change or clean nozzles in a multi-stage auto body washing/coating operation.

Solution: Total conversion from a threaded nozzle installation to a quick-change system reduced maintenance downtime from days to hours. Nozzles can be removed and replaced in seconds, by hand and without tools. As a result, there is improved product quality and a savings of about \$2000(US) per week in reduced maintenance time and labor.

Problem: A car wash operator was receiving increased customer complaints about their noticeably soiled vehicles after going through the wash. Business declined almost 15 percent in a two-month period.

Solution: An inspection of the washing system revealed several clogged nozzles along with distorted sprays from other nozzles. The brass tips had been in service two years with constant use. All showed dramatic wear and residue buildup. New stainless steel tips replaced the brass tips, and a new periodic maintenance program was initiated. The automobiles now emerge from the wash fully cleaned. Restoring lost business took nearly a year.

Replace Nozzles...But When?

To answer this question, here are the two major factors to consider:

- (1) the cost of wasted water, chemicals, and electricity; and
- (2) the deteriorating quality of the finished product and resulting rework, warranty and customer service problems. In spraying applications where the sprays do not directly contact the product being produced, such as in dust control, humidifying, gas scrubbing and cooling, spray drying, etc., the negative effects on the application results produce undesirable problems and costs.

Based on the experience at each installation, the operator can decide whether it costs more to keep using problem nozzles or replace them. After the spray application has continued for a reasonable period, criteria should be established for replacing the nozzles on a routine basis...for instance, such as after the flow rate increases, say, 15% above the catalog tabulated figure or over the flow rate of a new nozzle.

Judgments can also be made on the basis of using statistical process monitoring systems, which indicate the frequency and nature of the quality control problems caused by deteriorating-orifice spray nozzle performances.

As an example, after some study one steel mill has standardized on a routine 60-day descaling nozzle replacement schedule, while also monitoring the water supply system levels of suspended abrasives to determine when extreme wear conditions may exist and require shorter replace-

Problem: An Illinois farmer noticed some leaf burn on his soybean field several days after applying his herbicide.

Solution: He brought the problem to the attention of his local chemical dealer. A review of his spraying rig showed badly worn brass tips. In calibrating the spraying, it was determined that he had been overapplying by 17 percent. On his 320 acre soybean field, it was determined that herbicide waste was costing him about \$1,000(US) per application. This did not include any yield loss due to crop damage. New stainless steel tips were installed, providing proper coverage and eliminating chemical waste and crop damage.



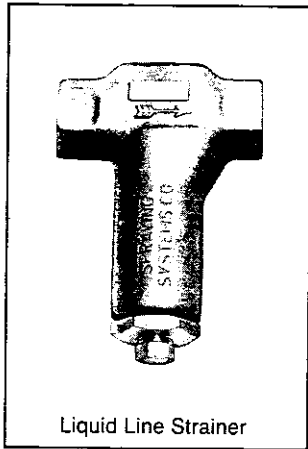
Poor solubility of spray dried milk products was solved with nozzles equipped with special carbide inserts.

Problem: Poor solubility of spray dried milk and whey products was being caused by variations in the size of the spray droplets. This resulted in excessive moisture content of the spray dried products. A complete inspection of the system revealed premature wear of the hardened stainless steel nozzle cores and inserts.

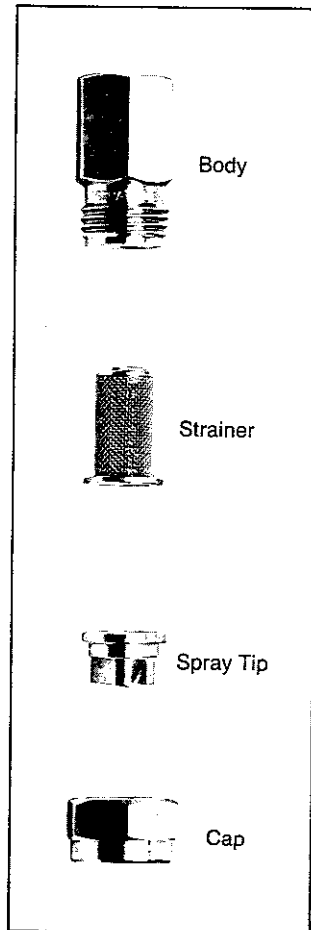
Solution: New nozzles equipped with special carbide inserts and cores were installed in place of the original stainless steel nozzles. The result was an immediate improvement in the solubility of the spray dried product. System performance is maintained through the plant's program of dryer maintenance. It includes regular inspection and cleaning of the nozzles to assure consistent product quality. Cores and inserts are removed from each nozzle cap, the system is flushed, and new or pre-cleaned cores and inserts are installed.



**Replace Nozzles...
But When?**



Liquid Line Strainer



Body

Strainer

Spray Tip

Cap

particles in the feed liquid, and changes in the sizes and shapes of the particles may reduce the wear effects. If corrosion is a problem, the corrosive activity of a solution can occasionally be reduced by using different concentrations and/or temperatures, depending on the specific chemicals involved.

In many applications, orifice deterioration and clogging is caused by solid dirt particles in the sprayed liquid. In spraying systems involving continuous spray water re-circulation, it's possible for water to be contaminated with dirt and debris which can cause orifice clogging and/or orifice wear. To minimize this type of nozzle problem, line strainers or nozzles with built-in strainers are recommended with a screen mesh size chosen to trap any particles larger than the orifice-free passage before they enter the nozzle orifice.

Prevent damage to the orifice during the cleaning process. As part of a standard nozzle maintenance and inspection procedure, nozzle orifices should be cleaned regularly and carefully, using cleaning probes made of materials much softer than the nozzle orifice surface. Otherwise the critical orifice shape or size can be permanently damaged, thereby resulting in distorted spray patterns and/or increased capacity.

Specifically, bristle brushes or wooden and plastic probes can be used, while wire brushes, pocket knives or welders' tip cleaning rasps are to be avoided. In some stubborn clogging problems, it is advisable to soak the clogged orifice in a non-corrosive cleaning chemical to soften or dissolve the clogging substance.

Change nozzle type or size. Occasionally, some nozzle problems are aggravated because an "improper" nozzle is being used. Therefore, if there is any question on this point, you should contact the nozzle manufacturer for ideas and suggestions.

What You Should Expect from Your Spray Nozzles

depends on what you're spraying and the nozzle material. You must consider the corrosive properties of the liquid being sprayed, its percent concentration and temperature, as well as the corrosion resistance of the nozzle material to this chemical.

Corrosion information on materials can be obtained from our company which maintains a reference library of corrosion tables and data from various chemical and material suppliers. Standard nozzle materials, depending on the nozzle type, include brass, steel, cast iron, various stainless steels, hardened stainless steels, many plastics and various carbides. On a special basis, the spray nozzles or spray tips can be supplied in other materials such as: CPVC and PVC, polyethylene, Teflon® nylon, ceramics, graphite, Hastelloy® Inconel® Carpenter 20® titanium, zirconium, Refrax® silicon carbide, Cupro Nickel® Ampco 8® and many other special materials.

Use lower spraying pressures. Although it's not always possible, this is another tactic to help decrease the orifice wear rate, because that rate is related to the velocity of the liquid through the orifice. Therefore, if you can use lower pressures which slow the liquid velocity through the orifice, this tends to reduce the orifice wear/corrosion rate.

Reduce the quantity of abrasive particles or concentration of corrosive chemicals. While these changes cannot be made in most applications, possible reductions in the amount of abrasive

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Consider Alternatives In Your Present Spray System

Use nozzle materials having better wear resistance. Materials having harder surfaces generally provide longer wear life. For each individual spraying job, there is a variety of nozzle, orifice insert and spray tip materials which should be considered so that you select the one which provides the service life you expect.

Approx. Abrasion Resistance Ratios of Typical Spray Nozzle Materials

| | |
|----------------------------------|------------|
| Aluminum | 1 |
| Brass | 1 |
| Steel/Iron | 1.5 to 2 |
| MONEL® | 2 to 3 |
| Stainless Steel | 4 to 6 |
| HASTELLOY® | 4 to 6 |
| Hardened Stainless Steel | 10 to 15 |
| STELLITE® | 10 to 15 |
| Silicon Carbide (Nitride Bonded) | 90 to 130 |
| Ceramics | 90 to 200 |
| Carbides | 180 to 250 |

Note: Nozzles and orifice inserts fabricated from other wear-resistant materials are also available on special request.

Because of the characteristics of some of the above materials, it is not practical to fabricate all nozzle types from all these materials. Also, plastic materials are not listed because the wide variety of plastics have different erosion and corrosion resistance properties and must be investigated individually.

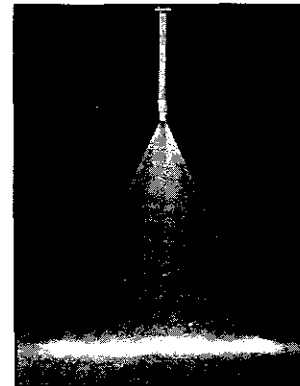
Our nozzle or material specialist can help you select the nozzle material best suited for each application. Many first-time applications begin with brass and are later upgraded to more wear-resistant materials —after their application performance has been approved.

Use materials with better corrosion resistance. The rate of chemical corrosion of solutions on specific nozzle materials

What You Should Expect from Your Spray Nozzles

Spray nozzles are precision components designed to perform specific functions. Their primary tasks may be well known in plants and commercial facilities world-wide, but a study of nozzle performance should begin with an understanding of the three functions commonly assigned to spray nozzles:

1. To meter liquid flow by providing a specific flow rate at a given pressure.
2. To provide a specific spray pattern. The choices are fullcone spray, hollow cone spray, flat spray or solid stream.
3. To break up or atomize liquid into small droplets. Such atomization can provide droplet sizes from 20 to 10,000 microns (micrometers) (1 in. = 25,400 microns), depending on the liquid, nozzle type and capacity, and spraying pressure.



In addition to these basic functions, nozzles also can perform other spray functions such as transforming liquid pressure into high velocity streams for pressure cleaning and descaling of steel by generating high impact. This impact force depends on many factors, including flow rate, spray pattern, nozzle type, spray distance, and spraying pressure, which is typically in the range of 300 to 3,000 psi.

Typical Checking Procedures

The following procedures are offered as random examples which apply only to a few selected applications. They are intended to serve as guides for setting up

procedures in other applications, based on priorities of quality control requirements in each specific application.

1 Flow Rate

Read flow meter

Collect spray in graduate or beaker

2 Spraying Pressure

Read pressure gauge

3 Spray Pattern

Check spray angle with protractor

Measure width of spray pattern on sprayed surface

Visually check spray pattern for spray uniformity

In critical applications, check spray pattern with special equipment

4 Product Quality

Check for uneven coverage of coating

In cooling application:
Check for signs of uneven cooling (such as on sheet steel)

In spray drying: Check powder moisture content

5 Application Results

For gas cooling check outlet gas temperature; for dust suppression, check dust content in environment; for humidity control, check relative humidity in room

Here is a typical spray nozzle maintenance program. While specific performance values will vary in each application, we've listed many of the factors to be considered for each individual application. You should adapt such a checklist for your own procedures based on the relative importance of these factors in each specific application.

Application Factors to be considered:

- 1 **Flow Rate**
each nozzle

 - 2 **Spraying Pressure**
in nozzle manifold

 - 3 **Spray Pattern**
each nozzle

 - 4 **Product Quality**
performed by Quality Control Department

 - 5 **Application Results**
as in dust control, spray drying, cooling gases, cooling water, humidifying, etc.
-

Each spray nozzle maintenance program should include only factors important to that specific application. Further, specific criteria for nozzle cleaning schedules and procedures and specific directions as to the time to replace nozzles and any other factors relevant to the application should also be included in the total maintenance program. Finally, the persons responsible for maintaining the program should be designated so that proper program control can be maintained.

Why You May Not Be Getting the Most from Your Spray Nozzles

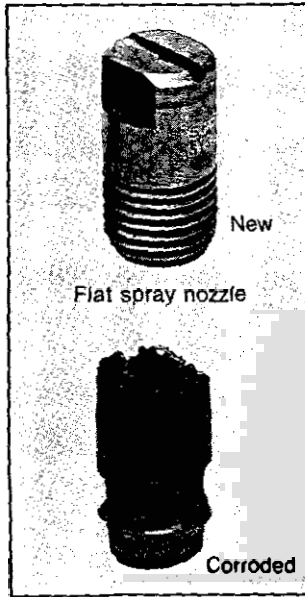
Spray Tips ...and Alternatives

The first and most important step in any spray installation is to choose the correct nozzle. The next, and also very important, step is to set up a spray nozzle maintenance program to monitor the nozzle's performance so that the desired spray application parameters will be properly maintained.

Each application has its own requirements and priorities in terms of spray nozzle performance characteristics. For instance, in some spray applications, the nozzles have only one purpose. That purpose could be *metering* a specific amount of liquid into batches, tanks, etc. In these applications, the priority would be to make certain that the *flow rate* of the nozzle is accurately maintained. In other applications, such as in coating applications, the *spray pattern* is as important as the flow rate, and both characteristics must be monitored. For high pressure spray cleaning and descaling applications, it is most important to maintain the proper *spray impact* by holding a constant pressure and spray pattern.

Please note: Photographs of worn or damaged nozzles illustrate extreme conditions of lack of proper maintenance. Nozzle problems should never be allowed to reach this stage.

Why You May Not Be Getting the Most from Your Spray Nozzles



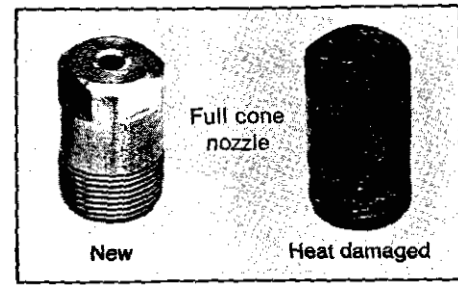
Nozzle performance can be compromised and even rendered totally ineffective by eroded, damaged, or obstructed nozzle orifices, the extent of which varies with nozzle type, size, and application.

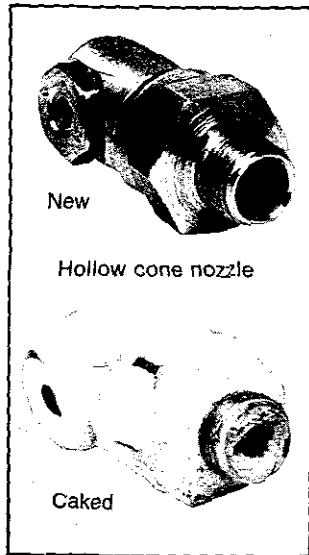
Here are the basic problems which can occur when the nozzles used are not well suited to the application, improperly installed or assembled, and/or not properly maintained.

Erosion/Wear. Gradual removal of metal from the nozzle orifice and internal flow passages which become larger and/or distorted. Flow is usually increased, pressure may be decreased, pattern becomes irregular, and the spray droplets become larger.

Corrosion. Breakdown of the nozzle material due to the chemical action of sprayed material or environment. Effect is similar to that caused by erosion and wear, with possible additional damage to the outside surfaces on the nozzle.

Temperature. Certain liquids must be sprayed at elevated temperatures or in high temperature environments. This may have an adverse effect on nozzle materials not intended for high temperature application. The nozzle may soften or break down.

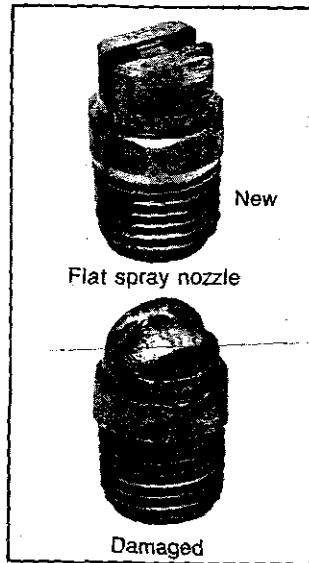




Caking. Buildup of material on the inside or outer edges of the orifice, caused by evaporation of liquid leaving a layer of dried solids and obstructing the orifice or internal flow passages.

Clogging. Unwanted solid particles blocking the inside of orifice, restricting the flow and disturbing spray pattern uniformity.

Improper Assembly. Some nozzles require careful re-assembly after cleaning so that internal components, such as gaskets, O-rings, and internal valves are properly aligned. Improper positioning may cause leakage as well as inefficient spray performance. Overtightening of nozzle caps onto bodies can cause thread stripping.

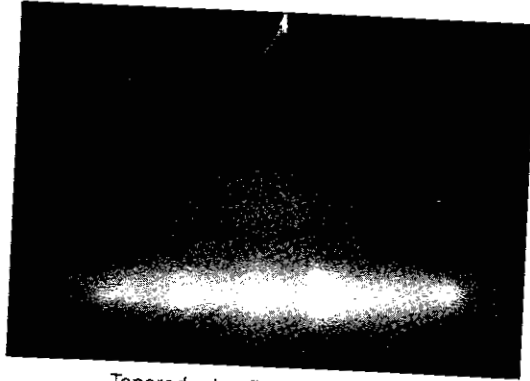


Accidental Damage. Damage to an orifice or nozzle by inadvertent scratching or by dropping during installation or operation. Also, smaller orifices can be severely damaged by use of improper tools during cleaning operation.

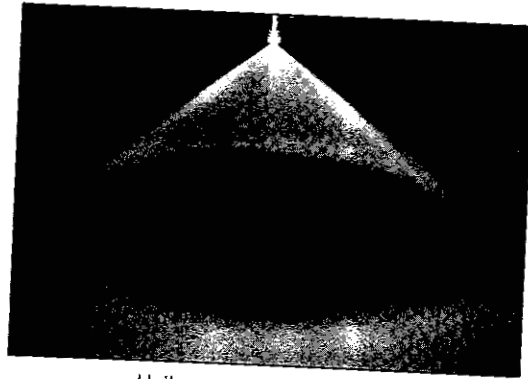
Please note: Photographs of worn or damaged nozzles illustrate extreme conditions of lack of proper maintenance. Nozzle problems should *never* be allowed to reach this stage.

Spray Problem Prevention... and Alternatives

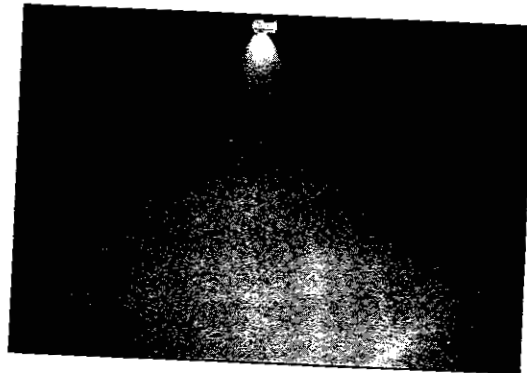
Examples of Good Spray Patterns



Tapered edge flat spray pattern



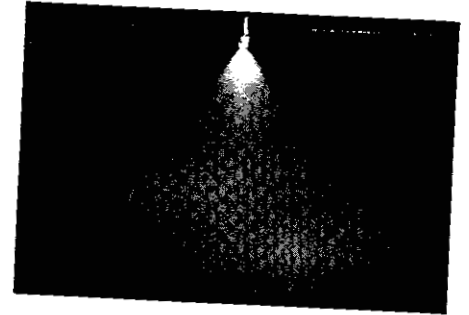
Hollow cone spray pattern



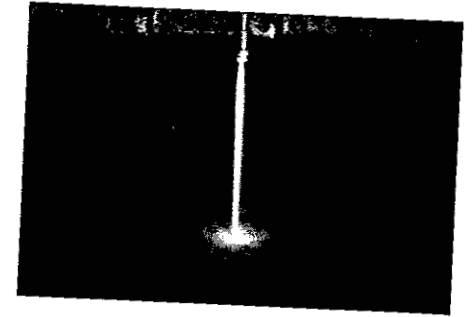
Full cone spray pattern

Example: Full Cone

Proper assembly



Improper assembly (without vane)



Example: Flat Spray

Clean nozzle



Clogged nozzle



If you are using a system fed by a positive displacement pump, however, the volume sprayed remains constant, while the spraying pressure declines as the orifice wears or corrodes. This lower pressure operation results in less spray impact on the sprayed surfaces. If the nozzle orifice becomes clogged, the spraying pressure would rise, possibly above the maximum pressure allowed in the system. This could cause damage and possible bodily harm to personnel.

A variation in spraying pressure can also produce a change in spray coverage.

Droplet Sizes. As the nozzle orifice wears or corrodes, flow rates increase or spraying pressures drop, thereby producing larger spray droplet sizes. In most operations, this problem cannot be visually noticed, but may be evident in application results.

Nozzle Alignment. When using flat spray nozzles on a manifold to provide an overall, uniform coverage on a web or sheet passing under the sprays, it is very important that all the nozzles be oriented correctly in relation to each other. That is, all the flat spray patterns should overlap, but not impinge on, adjacent spray patterns. All patterns should be parallel to each other. Otherwise, overall web coverage will not be uniform.

And you may find that more fluid is flowing through the center of the pattern causing a heavier liquid concentration. You might also see streaks and voids in the pattern.

For hollow cone spray nozzle patterns—essentially a circular ring of liquid—the pattern's uniformity will be disturbed by the presence of heavier "streaky" sections in some areas of the pattern.

For full cone spray nozzles which produce a round, square, or oval pattern completely filled with droplets, the pattern uniformity is affected somewhat the same as it is with flat spray nozzles because more liquid comes into the center of the pattern. Clogging of internal vanes of full cone spray nozzles produces an unpredictable distortion of the spray pattern.

Spray Pressures. A nozzle problem producing a pressure change may be difficult to notice. When using centrifugal type pumps, spraying pressures remain about the same, but the liquid volume sprayed usually increases as the orifice wears. This increased volume performance may result in increased costs of the liquid being sprayed.

Nozzle Problems: The Effects on Performance

How to Detect Nozzle Problems

The first gradual effects of nozzle problems are slight and often go unnoticed. However, as orifice deterioration continues, the changes in spray characteristics become noticeable and can be monitored.

Flow Rate. With centrifugal pumps, nozzle flow rates usually increase at a given pressure when the orifice continues to wear. Since this increased flow will not be visually noticeable, periodic flow rate checks are suggested, by checking flow meter readings, or, by collecting and measuring the *spray from the nozzle* for a given period of time at a specific pressure. These readings can then be compared to the flow rates listed in catalog tabulations *or compared to the flow rate readings from new, unused nozzles.* When using positive displacement pumps, orifice wear is accompanied by a drop in the liquid line pressure while the flow rate remains constant.

Spray Pattern. Visual inspection can easily reveal changes in the uniformity of flat spray patterns which are caused by orifice damage, clogging or caking; however, in cases where the orifice is wearing gradually, changes in spray pattern may not be detected until after the flow has increased substantially. In applications requiring accurate uniformity of spray coverage, special equipment or tests are required to check pattern uniformity.

A flat spray pattern from an elliptical orifice distributes the liquid as a flat fan or sheet-type spray with tapered edges, ideal for overlapping adjacent patterns. With increased orifice wear, you may be able to see and measure that the included angle of the spray pattern has decreased.

Nozzle Problems: The Effects on Performance

Damaged or poorly performing nozzles are like headlights with dirty lenses. You may not realize your lights are dangerously dim until you can't see the road ahead of you. The reduction of light has been almost imperceptible, yet hundreds of miles may have been travelled unsafely before you realized you could not see properly to drive.

Like headlights, nozzles which are dirty or damaged can cause operating problems. Several of the most common operating problems include:

Flow Rate Increase. In all nozzles, the flow rate will increase as the surfaces of the orifice and/or internal vane or core begin to deteriorate. With centrifugal, turbine or similar pumps which provide variable flow rates at relatively constant pressures, the increased flow rates can result in increased costs of wasted chemicals and water. Possible harm to the product or process quality can also result.

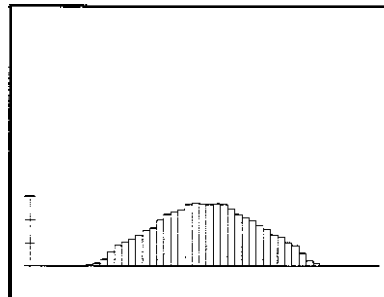
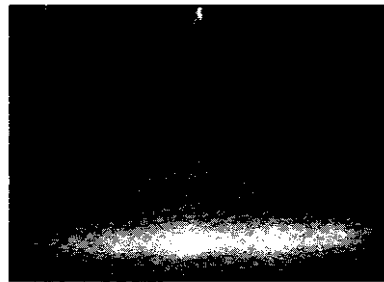
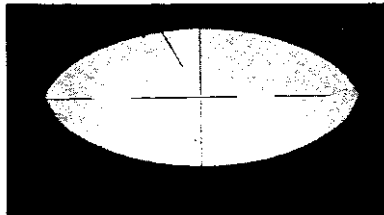
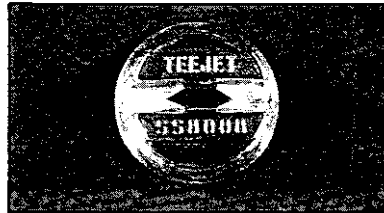
In applications using positive displacement pumps which provide the same capacity regardless of pressure, the spraying pressure will decrease as the nozzle orifice enlarges because of wear or corrosion. These lower spraying pressures deliver lower spray velocities resulting in less impact, which is not acceptable in applications such as high pressure cleaning and descaling.

Finally, the increased flow rates or lower spraying pressures also result in larger droplet sizes, which are undesirable in applications such as dust control, gas cooling or gas scrubbing.

Nozzle Problems Are Not Always Visually Apparent

These photographs demonstrate how spray problems go unnoticed. The tip on the left is new. The same size tip on the right has worn to the point at which it sprays 30% over capacity. Visual inspection of the tips and spray patterns shows little evidence of the wear. But a closer inspection and spray collection data reveal the difference between the two tips. All photographs are unretouched.

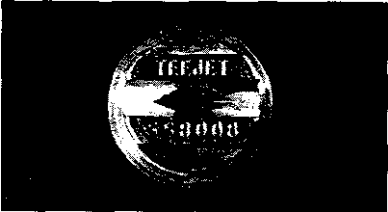
Good Spray Tip



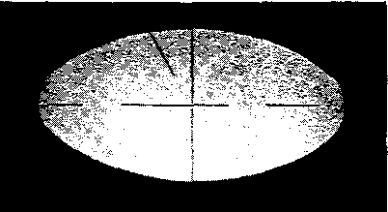
How to Detect Nozzle Problems

TROUBLE
CAUSING

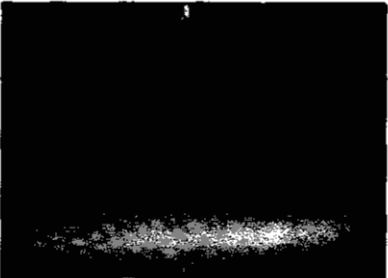
Worn Spray Tip



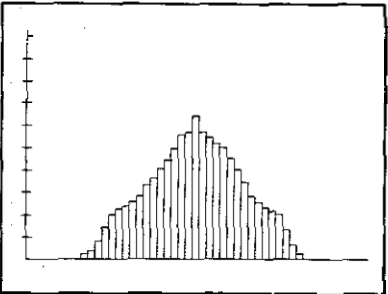
Nozzle tips show little visible difference



Orifice viewed through optical comparator shows evidence of internal wear.



Spray patterns of both tips show little difference.



Spray collection gives dramatic evidence of 30% increase in capacity.

Spray Pattern Quality. With hollow cone nozzles, as the orifice wear continues, the spray pattern uniformity is destroyed as streaks develop and the pattern becomes heavy or light in sections of the spray. In fullcone spray nozzles, the pattern distribution typically deteriorates as more liquid flows into the center of the pattern.

The pattern of flat fan sprays deteriorates by developing streaks and heavier flows in the center of the pattern, accompanied by a decrease in the effective spray angle coverage. Therefore, in applications depending on uniformity of overlapping spray patterns such as coating, these non-uniform spray patterns can seriously affect the application results on the finished product quality.

Spray Droplet Sizes. As the nozzle orifices wear or corrode, the liquid flow increases or the spraying pressure drops, thereby resulting in larger spray droplets. In applications in which the smaller droplet sizes result in higher efficiencies such as gas cooling, the formation of larger droplets results in less total liquid surface area, thereby resulting in less cooling of the hot gases.



One inch = 25,400 Microns
 One millimeter = 1,000 Microns

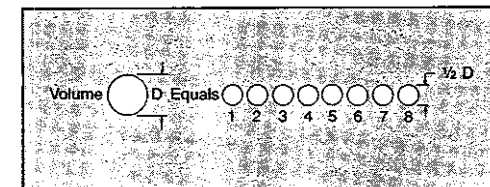
Other applications. In applications such as dust control, gas scrubbing, and humidifying, the droplet sizes are the most important factor. For instance, in applications involving the capture of airborne respirable dust (less than 5 microns), very small spray droplet sizes are required to capture these dust particles. Tests have shown that larger droplets are totally ineffective in capturing minute dust particles.

In humidifying applications, mist-sized droplets are needed for fast and complete evaporation. In spray drying, very small droplets are required to facilitate the 95% water evaporation required. In gas scrubbing such as SO₂ gas scrubbing applications, small droplets provide the largest total reagent chemical surface area for contacting and reacting with the SO₂ gas.

As nozzle orifices deteriorate, the droplets become larger resulting in (a) less efficient dust control, (b) reduced evaporating efficiency and (c) in the increased discharge of SO₂ gas into the atmosphere.

Droplet size information

The volume of one large droplet equals the volume of eight droplets with diameters one-half the size of the large droplet.



The surface area of the one large droplet is four times that of one small droplet. But the total surface area of the eight small droplets is twice that of the one large droplet.

droplets become larger and the cooling efficiency drops.

In spray drying applications, a liquid is sprayed into hot air or gas, where it dries and forms a powder. It must dry completely, usually into powder form, before it touches another surface. Here, too, worn nozzle orifices and cores create droplets which are too large and, thus, the powder particles are undesirably wet. Nozzle parts which are worn and produce inappropriately large droplets must be replaced.

In gas cooling applications, incomplete evaporation of droplets not only produces an inadequate cooling effect, but it also compounds the problem of disposing of non-evaporated water. It also adds to the deteriorating effects that moisture has on duct or chimney surfaces.

In cooling tower and spray pond water cooling applications, the larger spray droplets resulting from deteriorated nozzle orifices lower the water cooling efficiency of the installation.

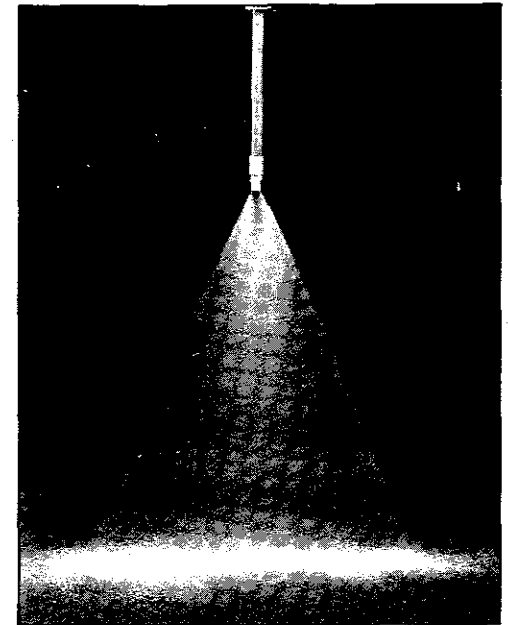


Typical spray dryer

Spray Impact. When used with positive displacement pumps, nozzles with worn orifices will operate at lower pressures, thereby lowering the impact on the sprayed surface. Centrifugal type pumps may actually increase the impact, because of the increased flow through the nozzle.

The effect of changes in flow rate, usually represented by the term GPM (gallons per minute) or l/min (liters per minute), and spraying pressure psi (pounds per square inch) or kilograms per square centimeter, can be determined by applying the following formula:

$$\begin{aligned} \text{Total Theoretical Spray Impact} &= \\ \text{In pounds: } &.0526 \times (\text{GPM}) \times \sqrt{\text{psi}} \\ \text{In kilograms: } &.024 \times (\text{l/min}) \times \sqrt{\text{kg/cm}^2} \end{aligned}$$



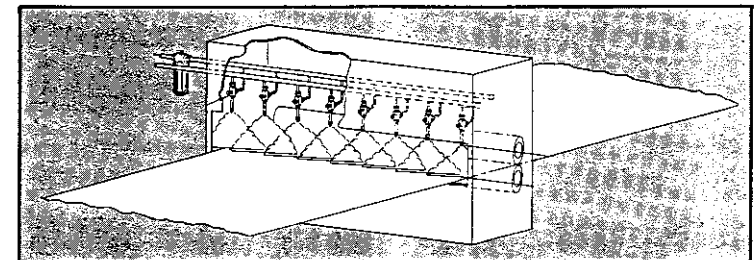
High pressure cleaning nozzle

Cooling. Applications in which sprays are employed to cool solid objects include the cooling of continuously cast steel, fabricated products, processing equipment, tanks, etc.

Nozzle problems in spray cooling of continuously cast steel can cause product distortion and cracks. And in roll cooling, uneven spray patterns result in uneven wear of the roll surfaces, leading to costly roll regrinding. So in addition to poor product quality, nozzle problems can cause excessive downtime.

When spraying is used to reduce the temperature of air and gases, pond water, and cooling tower water, the droplet size produced by the nozzles is most important. This is because the size of the droplets determines the total surface area of the water that contacts the air or gas.

In these applications, increased cooling efficiency is obtained by choosing spray nozzles that generate the largest total droplet water surface area per unit of water volume sprayed. Thus, these cooling applications usually require nozzles which generate smaller droplet sizes. And as these nozzles wear, the

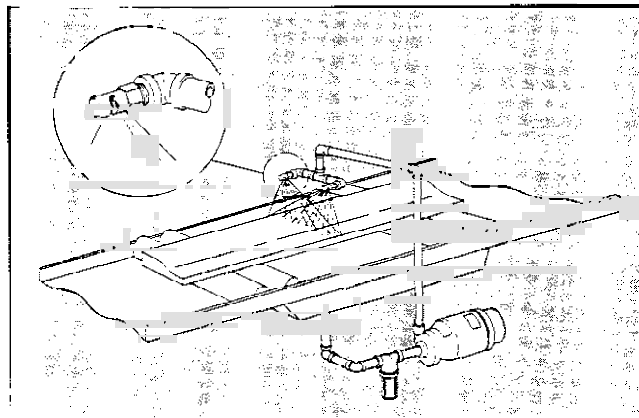


Sheet cooling prior to coiling

In low- and medium-pressure spray washing and cleaning operations using centrifugal type pumps, nozzle orifice wear problems cause an increased flow rate and uneven cleaning of a surface. This is because of spray pattern deterioration which will form streaks and heavy centers.

In high-pressure washers using positive displacement pumps, not only does the pattern gradually deteriorate but the spraying pressure drops, lowering the spray impact, which causes less effective cleaning. Such high pressure spray applications include car washing and the descaling of hot rolled steel. In these high-pressure systems, a drop in the liquid line pressure is a direct indication of an orifice wear problem.

Coating. The spray coating category includes the application of rust inhibitors, plastic coatings, release agents, lubricants, protective films, etc., as well as moistening and curing applications. In these installations, nozzle problems can waste expensive coating materials and/or apply uneven film or coating thicknesses on finished products. If the problem is associated with orifice wear, the nozzles or spray tips should be replaced.



Wood molding spray coating

Common Application Problems

Common Application Problems

Generally, spray applications can be described in one of four ways:

- (1) cleaning, washing and rinsing
- (2) coating
- (3) cooling of solid objects and air/gas
- (4) other applications, including
 - dust control
 - air and gas scrubbing
 - spray drying
 - humidifying

Malfunctioning nozzles produce various adverse effects depending upon the application.

Cleaning, washing, rinsing. These applications include medium- to high-pressure cleaning of products, vehicles, plant processing equipment, as well as high pressure descaling of hot rolled steel. Low pressure washing and rinsing installations are also included in this general category.



Circuit board rinsing