



How to Pre-empt a Significant Profit Drain: Nozzle Wear

Causes, Detection and Corrective Action Strategies

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KEY CONCEPTS

- Like any precision component, spray nozzles wear over time.
- Spray nozzle wear can be hard to detect. Small changes in performance can result in quality problems and wasted water, chemicals and electricity. The cost of using worn nozzles can be very significant – tens of thousands of dollars or more per year.
- Detecting nozzle wear in the early stages can prevent a significant profit drain.

Understanding the Costly Consequences of Nozzle Wear

Maybe you're thinking to yourself that the waste and inefficiency caused by using worn spray nozzles just can't be all that significant. If so, it's time to change your thinking and determine if nozzle wear is a problem in your operations. Like many other processors, you may discover that you are wasting millions of gallons of water, thousands of gallons of chemicals and incurring many other unnecessary costs due to using worn nozzles.

Once you appreciate the magnitude of the issue, you should be motivated to take immediate corrective action. In the pages that follow, you'll find information that will help you understand the causes of nozzle wear and what you can do about it.



Calculating the Costs

Using nozzles that are spraying just 15% over the rated capacity*:

WATER	
Waste	1,701,835 gallons
Cost of excess water:	\$4,680
CHEMICALS	
Waste	170,165 gallons
Cost of excess chemicals:	\$170,164
WASTEWATER DISPOSAL	
Waste	1,872,000 gallons
Cost of excess disposal:	\$7,956
Total Cost of Using Worn Nozzles: \$182,800	

*Based on total system flow of 100 gpm. Water cost of \$2.75/1000 gallons. Chemical cost of \$1.00 per gallon and a dilution ratio of 10:1. System operates 2080 hours per year. Increased electricity cost and scrap and downtime due to quality problems are not included.

Spray Nozzle Maintenance

Causes of Spray Nozzle Troubles

They may look simple enough, but spray nozzles are highly engineered precision components that can wear over time or suffer damage during normal operations or even cleaning. These are the most common problems that cause sub-standard spray performance:

Erosion/wear

Gradual removal of metal causes the spray nozzle orifice and internal flow passages to enlarge and/or become distorted. As a result, flow usually increases, pressure may decrease, the spray pattern becomes irregular and liquid drops become larger.



Accidental damage

Damage to a nozzle orifice can occur if a spray nozzle is dropped or scratched during installation, operation or cleaning.



Corrosion

Spray nozzle material can break down due to the chemical properties of the sprayed material or the environment. The effect is similar to that caused by erosion and wear, with possible additional damage to the outside surfaces of the spray nozzle.



Clogging

Unwanted solid particles can block the inside of the orifice. Flow is restricted and spray pattern uniformity disturbed.



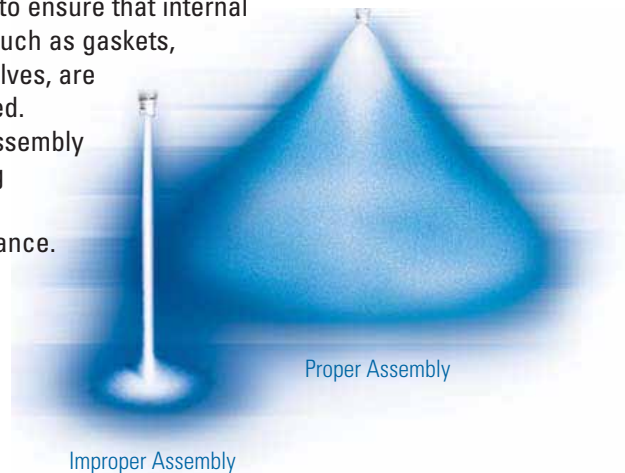
High temperature

Certain liquids must be sprayed at elevated temperatures or in high-temperature environments. The spray nozzle may soften and break down unless special temperature-resistant materials are used.



Improper re-assembly

Some spray nozzles require careful re-assembly after cleaning to ensure that internal components, such as gaskets, O-rings and valves, are properly aligned. Improper re-assembly causes leaking and inefficient spray performance.



Caking/bearding

Build-up of material on the inside, on the outer edges or near the orifice is caused by liquid evaporation. A layer of dried solids remains and obstructs the orifice or internal flow passages.

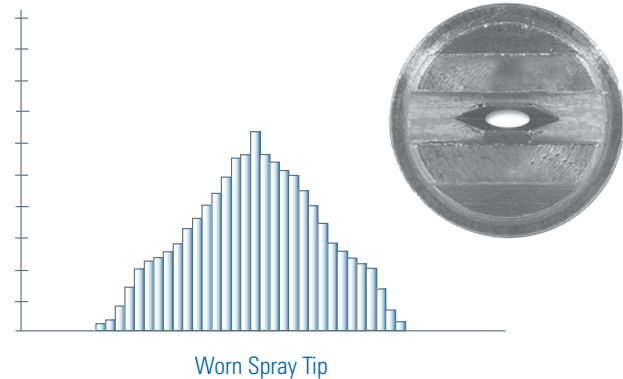
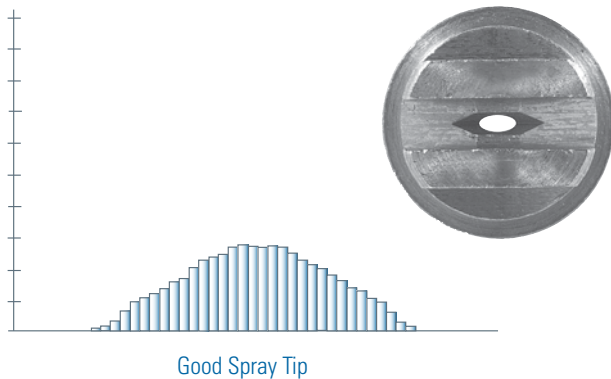


Nozzle Wear: Detection

Detecting Worn Spray Nozzles

This task is tougher than it sounds. The human eye is a remarkable instrument, but it simply can't give you the true story when it comes to actual spray nozzle wear.

The graphic illustrates this problem dramatically. The spray tip on the left is new, and sprays properly. The spray tip on the right is worn, and sprays 30% over capacity. The difference is totally undetectable by inspecting the nozzle, but spray collection data reveals the difference between the two tips.



To identify worn nozzles, look for these clues:

Quality control issues and increased scrap

Worn, clogged and damaged spray nozzles will not perform per specification, and can result in uneven coating, cooling, cleaning, humidifying and drying.

Increased maintenance time

Unscheduled spray system downtime, or an increase in cleaning frequency, is an indicator of spray nozzle wear.

Flow rate change

The flow rate of a spray nozzle will increase as the surfaces of the orifice and/or the internal core begin to deteriorate. In applications using positive displacement pumps, the spraying pressure will decrease as the spray nozzle orifice enlarges. Even small changes in flow rate can have a negative impact on quality, so routine monitoring can reveal potential problems. But in some instances, the spray pattern will look fine — so it will be necessary to actually collect and measure the spray fluid output in order to reveal wear.

Deterioration of spray pattern quality

When orifice wear occurs in hollow cone spray nozzles, spray pattern uniformity is destroyed. Streaks develop and the pattern becomes heavy or light in the circular ring of fluid. In full cone spray nozzles, the pattern distribution typically deteriorates as more liquid flows into the center of the pattern. In flat fan sprays, streaks and heavier flows will be visible in the center of the pattern and the effective spray angle coverage will decrease.

Spray drop size increase

Liquid flow will increase, or spraying pressure will decrease, as nozzles wear. The result? Larger drops and less total liquid surface area. This is tough to detect visually, so if you suspect a problem, arrange for drop size testing.

Lowered spray impact

Worn spray nozzles operate at lower pressure, generally resulting in lower spray impact. (Ironically, in applications with centrifugal-type pumps, impact may actually increase because of increased flow through the spray nozzle.) Special testing may be required.

Early Detection and Frequent Inspection Go Hand-in-Hand

Consistent evaluation of the following factors will enable you to detect wear early and take appropriate action. Your own particular application will determine how often each factor should be checked. The proper frequency could range from “the end of every shift” to “every few months.”

By implementing a nozzle inspection program and documenting your procedures, you can determine the best nozzle maintenance and replacement strategy for achieving optimal performance and controlling operating costs.

Be sure to check these factors carefully:

✓ Flow rate

For centrifugal pumps:

Monitor flow meter readings to detect increases.

Or, collect and measure the flow from the spray nozzle for a given period of time at a specific pressure.

Compare these readings to the flow rates listed in the manufacturer’s catalog or compare them to flow rate readings from new, unused spray nozzles.

For positive displacement pumps:

Monitor the liquid line pressure for decreases; the flow rate will remain constant.

✓ Spray pressure (in nozzle manifold)

For centrifugal pumps:

Monitor for increases in liquid volume sprayed.

The spraying pressure is likely to remain the same.

For positive displacement pumps:

Monitor pressure gauge for decreases in pressure and reduction in impact on sprayed surfaces. The liquid volume sprayed is likely to remain the same. Also, monitor for increases in pressure due to clogged spray nozzles.

✓ Drop size

Drop size increases cannot be visually detected in most applications. An increase in flow rate or decrease in spraying pressure will affect drop size.

✓ Spray pattern

Visually inspect the spray pattern for changes. Check the spray angle with a protractor. Measure the width of the spray pattern on the sprayed surface. If the spray nozzle orifice is wearing gradually, you may not detect changes until there is a significant increase in flow rate. If uniform spray coverage is critical in your application, request special testing from your spray nozzle manufacturer.



A Patterator measures spray distribution. The data is used to determine the optimal spray nozzle height and overlap in an application.

✓ Nozzle alignment

Check uniformity of spray coverage of flat spray nozzles on a manifold. Spray patterns should be parallel to each other. Spray tips should be rotated 5° to 10° from the manifold centerline.

✓ Product quality/application results

Check for uneven coating, cooling, drying, cleaning and changes in temperature, dust content and humidity.

Actual Drop Sizes

One inch = 25,400 μm

One millimeter = 1,000 μm

μm = micrometers



500 μm



1,200 μm



5,500 μm

Spray Nozzle Maintenance

Four Ways to Extend Spray Nozzle Life

There are some techniques you can employ to prolong the useful life of your spray nozzles.

1 Change nozzle material

Spray nozzles made of harder materials generally provide longer wear life. Predictably, stainless steel has a greater abrasion resistance ratio than aluminum, while carbides provide far greater abrasion resistance than stainless steel. To determine whether you should consider a different material for nozzles, spray tips or orifice inserts, consult the chart to the right.

In addition to abrasion resistance, you may need to consider the corrosion resistance of your nozzle material. The rate of chemical corrosion on a spray nozzle depends on several factors, including the corrosive properties of the liquid being sprayed, its concentration in the solution, its temperature, and the properties of the nozzle material. A leading spray nozzle company can analyze these factors and offer an appropriate recommendation.

Approximate Abrasion Resistance Ratios

Spray Nozzle Material	Resistance Ratio
Aluminum	1
Brass	1
Polypropylene	1 - 2
Steel	1.5 - 2
Monel®	2 - 3
Stainless Steel	4 - 6
Hastelloy®	4 - 6
Hardened Stainless Steel	10 - 15
Stellite®	10 - 15
Silicon Carbide (Nitride Bonded)	90 - 130
Ceramics	90 - 200
Carbides	180 - 250
Synthetic ruby or sapphire	600 - 2000

2 Add line strainers, or change to spray nozzles with built-in strainers

Orifice deterioration and clogging is typically caused by solid dirt particles in the sprayed liquid and is particularly common in systems using continuous spray water recirculation. Strainers, or spray nozzles with built-in strainers, are recommended — with a screen mesh size chosen to trap larger particles and prevent debris from entering the spray nozzle orifice or vane.



3 Decrease spraying pressure

Although it is not always possible to implement, decreasing the pressure — which will slow the liquid velocity through the orifice — may help reduce the wear and corrosion rate.

4 Reduce the quantity of abrasive particles or concentration of corrosive chemicals

In some applications, it is possible to reduce the amount of abrasive particles in the feed liquid, and/or change the size and shape of the particles to reduce wear effects. Also, the corrosive activity of a solution can occasionally be reduced by using different concentrations or temperatures, depending on the specific chemicals involved.

5 Consider the following:

Improve cleaning procedures Remember, nozzles are precision instruments. Cleaning should be done regularly but very carefully, with materials that are much softer than the nozzle orifice surface. Use plastic bristle brushes, wooden probes or plastic probes. Never use wire brushes, pocket knives, or welder's tip cleaning rasps. It is very easy to damage the critical orifice shape (or size) and end up with distorted spray patterns or excess flow. If you are faced with a stubborn clogging problem, try soaking the orifice in a non-corrosive cleaning chemical to soften or dissolve the clogging substance.



Clean nozzles with a material that is softer than the orifice, like a toothbrush or toothpick.

Spray Nozzle Maintenance

Replacement is the Ultimate Solution

Inspecting and maintaining your nozzles on a regular basis will help identify wear and extend service life. However, wear will invariably occur over time and the only solution is to replace your nozzles. The challenging part is determining when to replace them. Here are a few guidelines:

Are worn nozzles affecting product or process quality? If so, replace nozzles as soon as any wear is evident.

Is water conservation a priority? If so, replace nozzles as soon as wear is evident.

How much are you spending by continuing to use worn nozzles? That is, what are the additional costs for water, chemicals, electricity and wastewater disposal? How does that cost compare to the cost of replacement nozzles? Consider calculating the costs at different wear levels such as 10%, 15% and 20%. This will simplify future analysis as the cost of consumables rise. If you are not sure of the wear level of your nozzles, contact your spray technology supplier. The leading companies will conduct wear testing with specialized equipment at no charge for customers.

Is precise spray performance important to your overall process? If so, you may want to set pre-determined dates for nozzle replacement. Many companies change spray nozzles during annual or semi-annual maintenance shutdowns.

Your replacement schedule will depend on many specific operating conditions. Nozzles spraying abrasives at high pressures will wear much more rapidly than nozzles spraying water at low pressures. And, as discussed, many other factors can affect nozzles wear rates as well. The best way to pre-empt a significant profit drain due to nozzle wear is to take action before it becomes problematic. Investing some time now on nozzle inspection and calculating the cost of using nozzles spraying over capacity won't take long and can end up saving you tens or hundreds of thousands of dollars a year.

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Other Helpful Reference Material on Nozzle Wear

Optimizing Your
Spray System
**Technical
Manual 410**



Change the Way
You Spray to
Maximize Water
Conservation
**Technical
Manual 415**



www.spray.com/save
Online calculator to
help you calculate
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