Gas Cooling and Conditioning Guide
Using Spray Technology to Optimize Efficiency and Maximize Performance
Gas temperature, humidity and volume all need to be precisely controlled to avoid:

- Unexpected, costly downtime caused by ESP overload
- Decreased production levels due to gas volumes greater than the capacity of downstream equipment
- Excessive maintenance time caused by wetting and sludge build-up in towers and ducts
- Damage to downstream equipment from break away debris
- High energy costs due to operational inefficiency of the gas cooling system and downstream equipment
- Emissions exceeding environmental regulations and significant fines and penalties
- Tarnished reputation for not being a good corporate citizen

Evaporative cooling using dual-fluid atomization technology, where water is mixed with compressed air, has become the preferred method for gas conditioning because it typically offers greater precision than hydraulic cooling and lower operating costs. However, the performance of dual-fluid systems varies widely. It is important to understand the key system elements that determine the level of gas control you can achieve and to partner with a manufacturer that has all the resources to evaluate your requirements and help ensure performance goals are met.

Spraying Systems Co. is uniquely qualified to help you with your gas conditioning needs. We have more than 70 years of experience and our sole focus on spray technology has enabled us to develop the broadest product line of spray nozzles and systems in the industry and unique fabrication, research and testing services. As a result, we have solutions for NOx and SO2 control, cooling in ducts and towers and cooling prior to gas entry into baghouse, ESP, heat exchangers, kilns and more.

The Key to Effective Gas Conditioning and Cooling is Control

On the pages that follow, you'll learn more about our:

- High-efficiency FloMax® air atomizing nozzles that outperform all other similar nozzles
- Turnkey AutoJet® Gas Conditioning Systems that provide total automation and optimize the performance of FloMax nozzles
- Performance testing services in the world’s largest spray laboratory and the use of Computational Fluid Dynamics (CFD) to predict spray performance using actual operating conditions
- Standard and custom spray lances to ensure proper delivery of the liquid and gas to the spray nozzles
The most critical component in a gas cooling system is the spray nozzle

If drop size and spray coverage aren’t precisely right, problems like these can occur:

- Insufficient cooling
- Inadequate reductions in gas volume
- Wetting
- Increased energy consumption

All air atomizing nozzles are not alike

In fact, very few are suitable for gas conditioning. High-efficiency nozzles provide tight control of drop size and spray coverage. Very small drop sizes cannot be achieved with a single-step atomization process. A multi-stage process is required.

FloMax nozzles use a patented atomization principle to produce a highly focused air stream that shears the liquid with minimal air. The result of the unique process is that FloMax nozzles use less air and produce smaller drops than competitive nozzles.

The benefits of small drop size are many:

- Energy costs are lowered
- Small drop size equals greater liquid surface area for better chemical reaction
- Dwell time for complete evaporation is reduced
- The risk of wetting is reduced
- The liquid being sprayed generates more surface area per gallon (liter)

The uniformity of drop size distribution produced by FloMax nozzles ensures precise, tight control of drop size. This is another unique attribute – FloMax nozzles provide a narrower Relative Span Factor (RSF)* than many other air atomizing nozzles at most air pressures.

* RSF is a single number indicative of the uniformity of the drop size distribution. The closer the number is to 1, the more uniform the spray will be.
FloMax® Nozzles Outperform All Others

In addition to drop size, there are many ways FloMax nozzles provide superior performance

FloMax A series nozzles:

• **Maximum flexibility because of high turndown ratios**
  High turndown of flow rate – up to 10:1 – is possible. This allows the air pressure to be constant while the liquid varies based on process requirements.

• **Fewer nozzles required for cooling**
  FloMax nozzles offer a large flow rate per nozzle. Competitive nozzles with equivalent flow rates produce larger drops. Fewer FloMax nozzles can be used, resulting in lower initial costs and less maintenance time on an on-going basis.

• **Use lower quality water sources**
  FloMax A series nozzles feature large free passage. This means the risk of clogging is reduced, and lower cost water supplies such as river water, basins and run-off water can be used with confidence.

• **Reduced maintenance time**
  Durable, long-wearing parts require little maintenance. But when maintenance is required, it is fast and easy. Replacement of the nozzle or just the air cap and/or air annulus can be done without special tools. Competitive nozzles require more maintenance and more frequent replacement because of smaller free passages and the use of higher air and liquid pressures.

• **Effective even in harsh environments**
  A wide choice of materials ensures optimal nozzle performance even in high-temperature and corrosive applications. Typical materials include 316 and 310 stainless steel, HASTELLOY®, Stellite® and reaction-bonded silicon carbide. Others are available upon request.

Mounting options and easy installation

0°, 45° and 90° lightweight lances are available in standard materials with quick-release or bolt-on flanges and with quick delivery. Adapters, cooling jackets, purge tubes and protective tubes can be added. Custom lances in a wide range of materials and configurations for challenging spaces are also available.
**FloMax® X series nozzles:**

- **Wide operating range adds significant flexibility without compromising performance**
  FloMax X series nozzles have a liquid turndown ratio of up to 10:1. This allows the air pressure to be constant while the liquid varies based on process requirements. The 10:1 turndown ratio far surpasses conventional air atomizing nozzles with ratios of 2:1 or 3:1.

- **Narrow spray angle is ideal for targeted sprays in critical applications**
  The narrow 20° spray angle is well suited for applications where tight control of drop size and spray precision are important. Multiple nozzles can be configured on a lance or in a duct or vessel to deliver sprays to a precise position or area. A 55° spray angle is also available for applications requiring more spray coverage.

- **Suitable for demanding applications**
  Material options include 310 and 316 stainless steel and HASTELLOY®. Other materials are available upon request.

- **Minimizes clogging due to a large free passage**

- **A choice of mounting options and easy installation**
Optimized performance and total automation

If you think of FloMax nozzles as the heart of your gas cooling operation, the AutoJet Gas Conditioning System is the brain. It controls all system components and ensures optimized performance without operator intervention.

Nine benefits the AutoJet System can bring to your gas cooling application

1. **Optimal performance**: Our AutoJet spray controller, with patent-pending SprayLogic® software, monitors and automatically adjusts the closed loop system. By regulating liquid and air flow to the nozzles based on data gathered from RTD temperature sensors, the controller offers the highest level of reactivity and accuracy for the system.

2. **Plug and spray convenience**: Pre-programmed with parameters and function screens specific to gas conditioning applications, our controller will save you time and money during installation. Full LabVIEW® simulation and system pre-testing prior to shipping ensure full functionality upon set-up.

3. **Total automation minimizes labor and downtime**: The AutoJet spray controller controls all system components – nozzles, pumps, sensors and other hydraulic/pneumatic components. If a problem is detected that the controller can’t resolve automatically, operator warnings will be displayed or sounded.

4. **Multiple lance zones**: AutoJet Gas Conditioning Systems can be configured with multiple lance zones to allow greater turndown of flow rate under variable system conditions.

5. **Built for reliability**: Emergency modes, system redundancy, intelligent fault sensing and patent-pending continuous system integrity checking are just a few of the reasons why you can count on long-term, trouble-free performance.

6. **Reduced energy costs**: Variable Frequency Drive (VFD) pumps provide proportional liquid regulation and significant electricity savings. In addition, energy-efficient proportional air regulation reduces air consumption and operating costs.

7. **Easy integration**: You can easily integrate the AutoJet Gas Conditioning System with other systems through direct wiring and current splitters for access to critical data. For full control of all available data, an optional OPC communication link is available.

8. **Ease of use**: Our controller is easy to use and is equipped with complete spray “knowledge.” Just provide information about your operation using the menu system and the controller will essentially configure itself.

9. **Single source convenience**: Should you have a question about your system, just give us a call. No need to contact multiple suppliers and coordinate their efforts should a problem occur.
How it works and how you’ll save

Potential savings using an AutoJet® System and FloMax® nozzles

- 5% savings on installation compared to hydraulic systems
- 30% less in electricity
- 50% less in replacement parts
- 75% less in labor/maintenance

Estimated first year savings: US $20,000
Estimated ongoing annual savings: US $12,000
Spray Testing and Modeling
Predetermine performance

Understanding drop size in gas cooling applications is critical

Many problems result from premature or incomplete evaporation. If drops evaporate too quickly, the desired level of absorption may not occur and upstream/downstream equipment may be less efficient or damaged. If drops don’t evaporate quickly enough, wetting will occur, entrained liquid may result and dust can accumulate in the duct or tower and obstruct gas flow.

In many cases, running sophisticated gas cooling calculations provides enough information to determine the number of nozzles required and how they need to be positioned. However, with complicated gas flows, unusual operating conditions or atypical duct work or tower shape, gas cooling calculations alone may not tell the entire story. This is when we head to our spray laboratories and conduct spray characterization studies to determine dwell time simulating actual operating conditions.

Typically these studies include:
• Drop size testing to determine the optimal drop size and drop size distribution
• Determination of gas velocity and density and the resulting impact on drop size

Spray Analysis and Research Services, a service of Spraying Systems Co., is our research and testing group that operates the most fully equipped spray laboratory in the world. Phase Doppler Particle Analyzers, Laser Imaging, Particle/Image Analyzers and Laser Diffraction Analyzers are among the instruments we use to measure drop size.

Drop size data: what you need to know

Drop size is the critical consideration in evaporative cooling. It impacts virtually every aspect of gas cooling and can have a significant impact on cooling effectiveness.

Drop size refers to the size of the individual spray drops that comprise a nozzle’s spray pattern. Each spray provides a range of drop sizes. This range is the drop size distribution.

Key drop size definitions

$D_{\text{max}}$: This is the maximum drop size by volume present in the spray. The diameter is also used when complete evaporation of the spray is required.

$D_{32}$ – Sauter Mean Diameter (SMD): This expresses the fineness of a spray in terms of the surface area produced by the spray. The SMD is the diameter of a drop having the same volume to surface area ratio as the total volume of all the drops to the total surface area of all the drops.

$D_{95}^*$: This is the value where 90% of the total volume of liquid sprayed is made up of drops with diameters smaller or equal to this value.
Computational Fluid Dynamics (CFD) and gas conditioning

CFD is the science of predicting:
- Fluid flow
- Heat transfer
- Mass transfer
- Chemical reactions

CFD uses numerical methods and algorithms to solve and analyze problems involving fluid flows. Sophisticated software performs the millions of calculations required to simulate the interaction of fluids and gases with related physical phenomena.

Some spray operations cannot be replicated in our labs. While we can spray solutions other than water, there are some gases and liquids that are not safe to use during testing. Plus, it is not always feasible to reproduce some mixing conditions and chemical reactions. While we often build enclosures and/or spray headers to simulate actual spraying conditions, it is not practical to construct some structures and spray environments. That’s when we rely on our extensive library of proprietary spray characterization data and CFD.

We use CFD to predict:
- Liquid and gas flow in scrubbers, towers and ducts
- Internal flow characteristics in spray nozzles
- Gas and liquid mixing in dual-fluid nozzles

CFD models illustrate flow patterns, velocity, temperature, gas/liquid distributions, droplet trajectories, pressures within the entire system and impact forces and stress caused by liquid flow.
Flowback Nozzle Systems

The hydraulic solution

When dwell time isn’t critical,
Flowback nozzle systems are the best choice

In applications where compressed air isn’t a desirable option or residence time for complete evaporation is not critical, our Flowback hydraulic nozzle system can help you improve performance. Constant pressure is applied to the nozzle at all times to produce a consistent drop size. When the desired gas temperature is reached and a reduction in volume is called for, a valve is adjusted to alter the amount of fluid leaving the nozzle. The excess fluid is allowed to “flow back” through the center orifice of the nozzle body. The nozzle offers a 10:1 turndown ratio to accommodate variations in gas temperature or volume.

Our turnkey AutoJet® Gas Conditioning Systems can be supplied with Flowback nozzles upon request.

If you are maintaining a hydraulic system, consider a change to Flowback nozzles

• Easily interchangeable with competitive nozzles
• Durable construction – resistant to damage unlike more delicate competitive nozzles
• Simple, unique two-piece design
• No special tools required for installation or maintenance
• Large selection of nozzle capacities

Advantages of a Flowback nozzle system

Flowback nozzle
Sizes range from 1.2 to 45 gpm (4.5 to 170.3 l/min) at 600 psi (41.4 bar). A simple but unique two-piece design makes installation and maintenance quick and easy. No special tools are required — the orifice slides into the nozzle and can be tightened with a wrench.

Competitive nozzle
Complex bellows design with four separate components. The design of these nozzles is delicate. As a result, they are often damaged during operation or maintenance. Internal leaking, poor atomization and wetting in the tower result. Special tools are required for both installation and maintenance.
Solutions That Work for Your Peers
May Help You Boost Performance Too

Efficient gas cooling
improves production

Small droplet sizes produced by FloMax® air atomizing nozzles allow greater volumes of gas to be cooled without wetting, which eliminates maintenance headaches.

Induct chemical injection

High-efficiency FloMax air atomizing nozzles are used to inject a proprietary chemical into the gas stream to reduce corrosiveness and help protect the costly catalyst grid downstream.

Selective catalytic reduction (SCR) NOx control

Precise control of urea injection and distribution using FloMax air atomizing nozzles improves chemical reaction, reduces ammonia slip and prevents fouling of the catalyst grid.

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Semi-dry scrubbing for SO₂ removal

FloMax air atomizing nozzles provide precise cooling prior to heat exchanger. Complete evaporation prevents fouling of the heat exchanger, eliminating costly maintenance and downtime.

These are just a few examples of our successful gas conditioning solutions. Contact us to learn how we can help you.
Other Helpful Resources

FloMax® Air Atomizing Nozzles
Bulletin 487C
Features details and performance data on the unmatched energy-efficient FloMax nozzles and lances.

Spray Technology Reference Guide: Understanding Drop Size
Bulletin 459B
An invaluable technical guide. We've taken 60 years of spray drop knowledge and condensed it into a 36-page booklet to teach you the fundamentals of evaluating and interpreting drop size data.

FloMax Nozzle Performance Data
Contact your local sales office for comprehensive performance data, dimensional information and more.

Optimizing Production with Precision Spray Control
Bulletin AT103B
Provides an overview of the benefits of automated spray systems. Included are application examples that show how to reduce overspray, improve product quality, increase throughput and improve regulatory compliance.

Flowback Nozzle Performance Data
Contact your local sales office for comprehensive performance data, dimensional information and more.

Optimizing Your Spray System: Spray Nozzle Maintenance and Control for Improved Production Efficiency
Technical Manual 410
Explains how to evaluate your spray system, uncover and solve costly hidden problems, improve quality, reduce maintenance downtime and more.

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Experts in Spray Technology

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