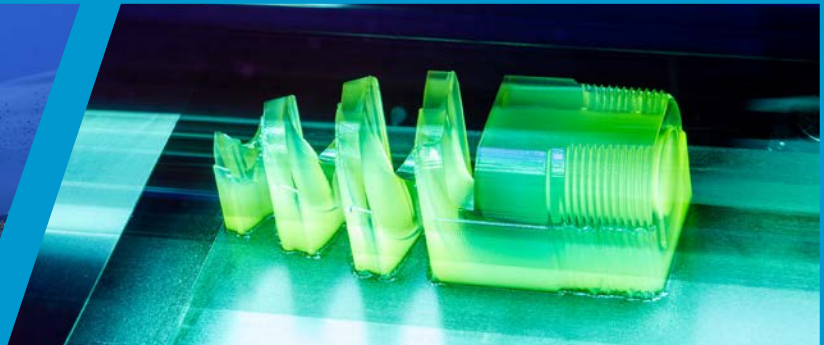


# PETROCHEMICAL PROCESSING

## SPRAY NOZZLES, FABRICATIONS, & SYSTEMS



## TABLE OF CONTENTS

- 3 The BETE Advantage
- 4 Spray Nozzles for Petrochemical Applications
- 6 Spray Technology for Petrochemical Processing
- 7 Chemical Spray Injection
- 10 Gas Scrubbing
- 12 Gas Cooling & Conditioning
- 14 Tank Cleaning
- 16 Fire Protection
- 18 Manufacturing Services
- 19 Spray Fabrication Services
- 20 Engineering Services
- 21 Advanced Engineering
- 22 Spray System Solutions

# PERFORMANCE SPRAY ENGINEERING

BETE is a fourth-generation family-owned company with decades of experience providing innovative spray solutions to the chemical processing industry. We make tens of thousands of different products, including fog and misting nozzles, tank washing nozzles, material injection nozzles, custom spray lances, fabrications, and spray systems. Our high-quality spray technology is manufactured with durable and corrosion-resistant materials to perform in the harshest environments.

**We know that selecting the correct nozzle for your process is key to optimizing productivity.** Our customer-focused designers, applications engineers, and sales team work with you to find the best spray solution for your unique application, whether it be a standard product or a custom design.

Our Advanced Spray Engineering Services are offered to solve your more challenging and critical problems and include CFD studies and physical testing. Our decades of experience in spray design and Applications Engineering, combined with our CNC machine shop, foundry, and spray laboratory, are used to design, manufacture, and test new products.

**BETE's mission goes beyond just selling spray nozzles. It is to provide engineered spray process solutions that exceed customer's expectations in every detail. From initial discussions to design, fabrication, and ongoing service – we will make your project a success.**



Spray  
Nozzles



Spray  
Fabrications



Spray  
Systems



Applications  
Engineering
























Spray  
Research

# THE BETE ADVANTAGE



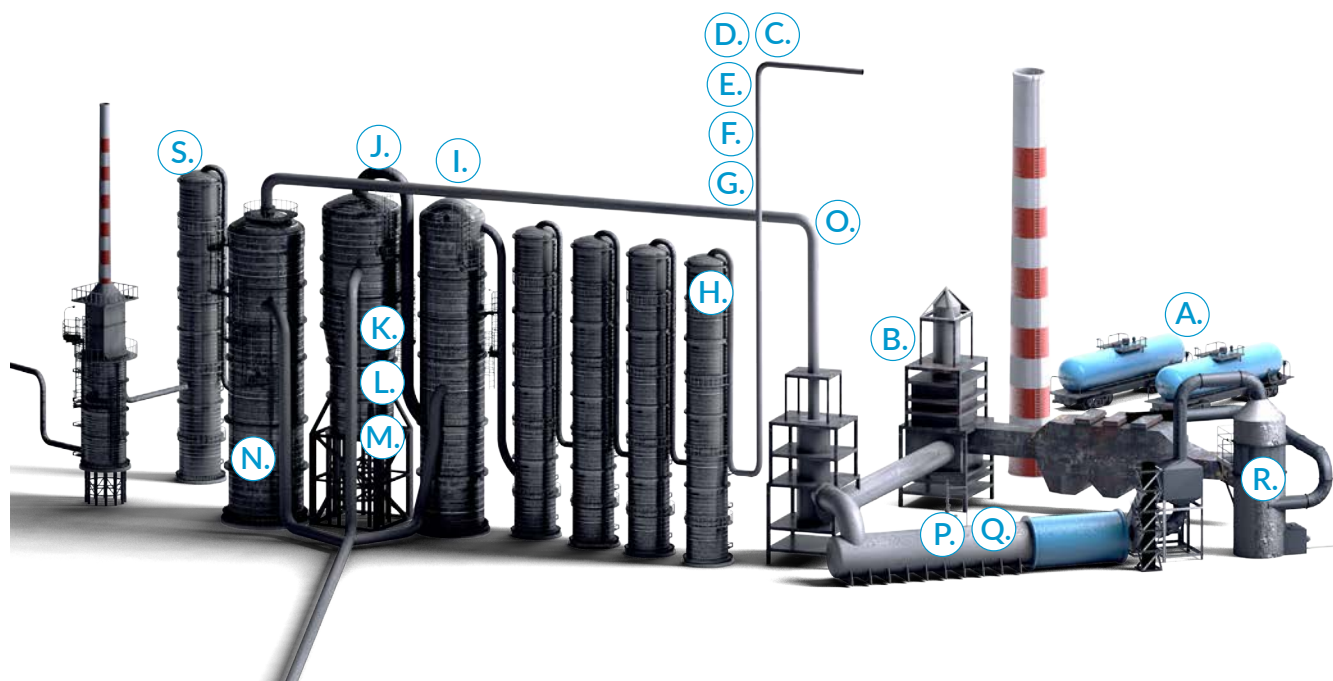
# COMMON SPRAY NOZZLE SOLUTIONS FOR PETROCHEMICAL PROCESSING

	 FULL CONE			 HOLLOW CONE			 FAN	 MISTING	 AIR ATOMIZING	 TANK CLEANING	 TANK MIXING	 FIRE SUPPRESION	
APPLICATION	 Spiral	 Axial	 Tangential	 Spiral	 Axial	 Tangential							
Absorption (Gas Washing)													
Amine Scrubbing													
Catalyst Reformer Gas Cooling													
Chemical Injection													
Chloride Injection													
Corrosion Inhibitor Spray													
Coker Off-Gas Cooling													
Desuperheating (Water Injection)													
Defoaming													
Electrostatic Precipitator (ESP -Pre-scrubbing and gas cooling)													
Electrostatic Precipitator (Particulate washing collection tube or plate)													
Electrostatic Precipitator (Particulate washing )													
FCC Overhead Wash													
Fractionator Wash Water Injection													
Fire Suppression													
Flue Gas Desulfurization													
Gas Cooling (Quenching Oil)													
General Wash for process piping, condenser and columns													
Heat Exchanger Cooling/Washing													
Mix Temperature Control													
Packed Tower Cleaning													
Quenching Water													
Rail Car Cleaning													
Regenerator Bypass													
SCR NOx Control													
SNCR NOx Control													
Slurry Back Flush Injector													
Spent Acid/Sulfur Regeneration Nozzles (SAR)													
Steam Condenser Spray													
Steam Quench Injector (LCO Injection)													
Tank Cleaning													
Torch Oil													
Vacuum Distillation Column													
Water Washing of Salts													



# SPRAY TECHNOLOGY FOR PETROCHEMICAL PROCESSING

Among a long list of industries, refineries and chemical plants have counted on BETE's nozzle engineering expertise for decades to supply fabricated spray assemblies designed from the nozzle up. Starting with the process conditions, we recommend the most appropriate nozzle and incorporate it into a fabricated lance, spool, or another assembly that meets all mechanical design criteria. Working with BETE as your primary fabricator ensures all components fit and work together seamlessly.



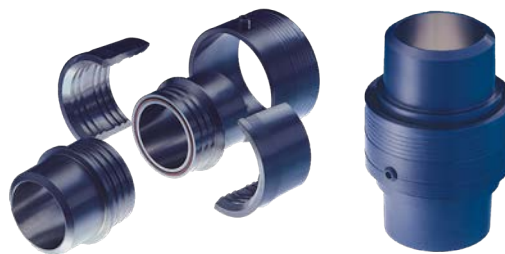
A. Railcar Tank Cleaning  
B. Heat Exchanger Cooling & Washing  
C. Chemical Injection  
D. Steam Quench Injection  
E. Catalyst Reformer Gas Cooling  
F. Chloride Injection  
G. Desuperheating

H. Vacuum Distillation Column  
I. Fractionator Water Wash Injection  
J. FCCU Overhead Wash  
K. Mix Temperature Control  
L. Slurry Back Flush Injection  
M. FCCU Feed Injection

N. Torch Oil Injection  
O. Coker Off-Gas Cooling  
P. SNCR NOx Control Injection  
Q. SCR NOx Control Injection  
R. Flue Gas Desulfurization Injection  
S. Distillation Column Injection

## DUR O LOK® PIPE COUPLINGS

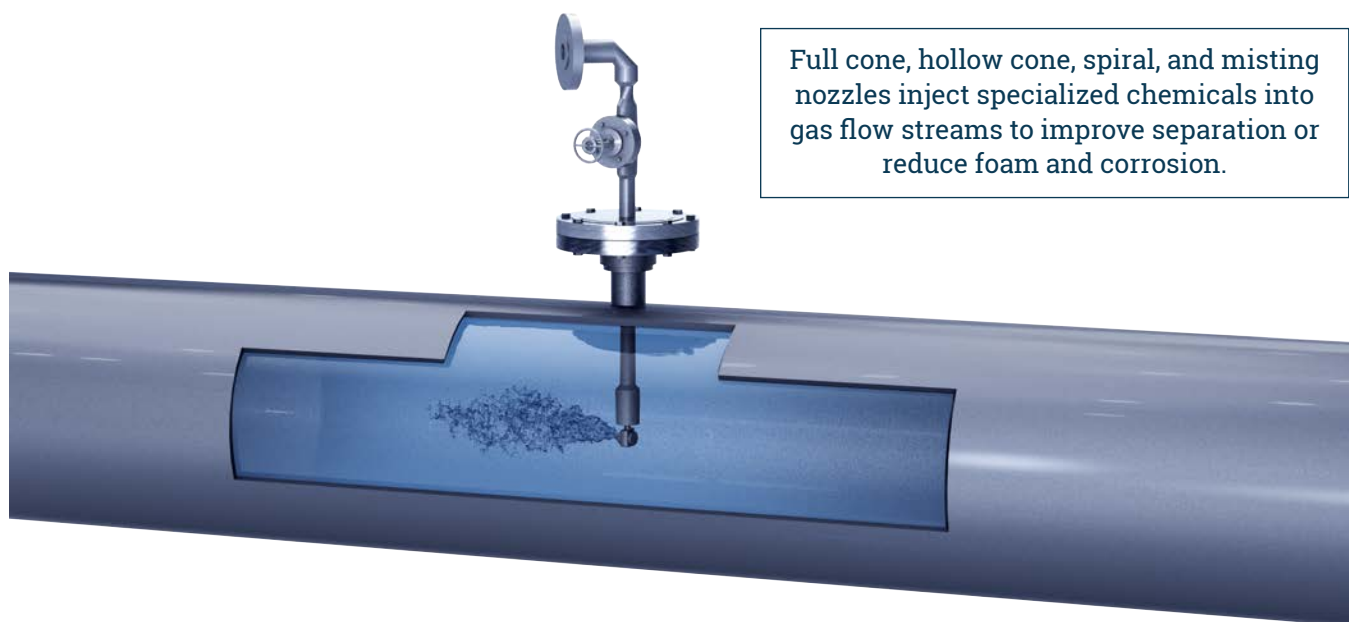
Replace standard ANSI flanges with Dur O Lok threadless, boltless, light weight pipe couplings. Reduce maintenance, material costs, and space requirements for pipe racks in refinery applications over a wide range of temperatures.



# CHEMICAL SPRAY INJECTION

## CHEMICAL INJECTION INHIBITORS

Systems and processes can suffer from performance issues related to corrosion or scale buildup in components such as piping, heat exchangers, pumps, and valves. Corrosive decay can affect the safety and integrity of a system by degrading materials and components. Scale buildup may affect the efficiency of a process by decreasing flow passages and potentially blocking all or part of a process stream. Heavy scale buildup has the potential to break off and clog or damage downstream equipment.



**BETE spray nozzles maximize efficiency in inhibitor injection applications as they atomize and distribute the inhibitor liquid into the vessel or process stream. Compared to open-ended injection quills, these specialized spray patterns improve the coverage and reaction with chemicals and compounds that may cause corrosion or scale formation.**

### COMMON APPLICATIONS

- Heat exchangers
- Injection of inhibitors such as MEG and methanol

## SCAVENGER INJECTION

Scavengers are liquid chemicals that neutralize and remove small amounts of hazardous or problematic compounds, typically hydrogen sulfide ( $H_2S$ ), from bulk fluid streams.  $H_2S$  removal is critical to prevent expensive infrastructure damage and to ensure compliance with environmental and safety regulations.

**Compared to open-ended injection quills, BETE spray nozzles maximize efficiency in scavenger injection applications. They atomize and distribute the neutralizing liquid into the process stream, increasing the reaction surface area for  $H_2S$  other problematic compounds in the pipeline.**

## RECOMMENDED NOZZLES FOR INHIBITOR AND SCAVENGER INJECTION



**MPL**  
Low Flow  
Full Cone Nozzle



**MaxiPass®**  
Maximum Free Passage  
Full Cone Nozzle



**WTZ**  
Right Angle  
Full Cone Nozzle



**TF**  
Hollow Cone or  
Full Cone Spiral



**CW**  
Low Flow Full or  
Hollow Cone Nozzle



**WT**  
Tangential Whirl  
Hollow Cone Nozzle



**MicroWhirl®**  
Atomizing  
Misting Nozzle



**PJ**  
Impingement  
Misting Nozzle



**L**  
Low Flow  
Misting Nozzle



**XA**  
Low Flow  
Air Atomizing Nozzle

## SPRAY LANCES FOR CHEMICAL INJECTION

Spray nozzles coupled with BETE spray lances can distribute the inhibitors or scavengers evenly along the centerline of process streams or vessels.



## WATER WASH INJECTION

Injection of wash water into process lines for refining, petrochemical, and chemical processing cleans contaminants from gas streams and piping components. For example, the water wash process plays a vital role in refining crude oil into its component fractions. Initially, injected wash water removes salts and halides from the crude through precipitation before they start to corrode and degrade the refining system itself. Downstream in the refining process, water wash injection nozzles spray into the hydrocarbon streams to clean away residual solid particles.



Spiral full cone nozzles are used to inject water or other fluids into the process lines to remove particulate, chemicals and salts to prevent corrosion.

**BETE spray nozzles maximize efficiency in wash water injection applications by atomizing and distributing the wash water into process streams or vessels, increasing the water's coverage and reaction surface area.**

Spray nozzles coupled with BETE spray lances will distribute the wash water as evenly as possible along the centerline or desired areas of process streams or vessels.

### COMMON APPLICATIONS

- Fractionator water wash injectors
- Scrubbing crude oil of corrosive salts and halides
- Distillation column wash water injectors
- Removing particulates from a process stream

## RECOMMENDED NOZZLES FOR WASH WATER INJECTION



**WL**  
Axial Low Flow  
Full Cone Nozzle



**MaxiPass® (MP)**  
Axial  
Full Cone Nozzle



**NCS**  
Low Profile Axial  
Full Cone Nozzle



**TF**  
Spiral  
Full Cone Nozzle



**TF**  
Spiral  
Hollow Cone Nozzle



# GAS SCRUBBING

Scrubber nozzles remove pollutants and other chemical contaminants from process gases, liquids, and equipment. Scrubbers also remove acids from chemical processing off-gases.

## OPEN SCRUBBERS

In open scrubbers, nozzles spray the scrubbing liquid directly into the process stream. Open scrubbing depends on the correct droplet size and process conditions to maximize the reaction or mass transfer rate. These are usually dependent on the surface area to volume ratio of the droplets.

## PACKED SCRUBBERS

In packed bed scrubbers, scrubbing fluids are distributed over packing material in a column or vessel, creating a thin film of liquid on the packing. The gas passes upward through the packing. It contacts the liquid film, providing an opportunity for high surface area contact between the liquid and the gas.



A Venturi scrubber is a wet-scrubbing process that uses direct contact between the gas and the liquid scrubbing agent. Water or other scrubbing fluids are usually sprayed axially into the narrowest section of the duct. The shear forces applied to the droplets caused by the high velocity, turbulent air atomizes the water quickly and provides adequate mixing

## RECOMMENDED NOZZLES FOR GAS SCRUBBING



**MaxiPass® (MP)**  
Axial  
Full Cone Nozzle



**NC**  
Axial Whirl  
Full Cone Nozzle



**NCJ**  
Narrow Angle  
Hollow Cone Nozzle



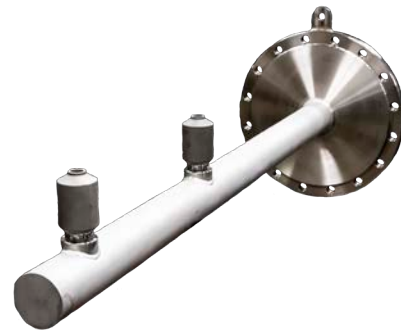
**NCK**  
Narrow Angle  
Full Cone Nozzle



**TF**  
Hollow Cone or  
Full Cone Nozzle

## SPRAY LANCES FOR GAS SCRUBBING

BETE can design and fabricate a spray lance solution to inject liquid or gas precisely into a process stream. BETE offers both stationary and retractable lances. Retractable lances allow inspection and service of the nozzles without downtime.

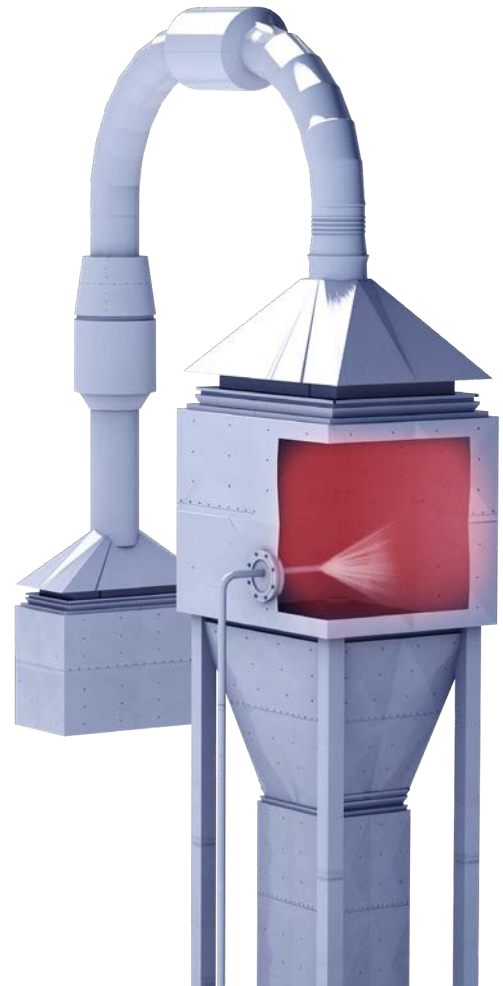


## NOX REMOVAL (SCR/SNCR)

NOx causes air pollution by reacting with air in UV light from sunlight to form ozone, the primary component of smog. Therefore, it is crucial to limit NOx emissions in applications that produce large quantities of these gases.

In both selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR), spray nozzles inject a reagent or series of reagents into the exhaust gas to combine and react with the gas (and potentially a catalyst) to remove NOx from emissions. SCR uses ammonia as the reagent, while SNCR uses ammonia or urea injected at a high temperature.

BETE spray nozzles maximize efficiency in SCR/SNCR injection applications. They atomize and distribute the reagent into the process stream, increasing the reaction surface area that combines and reacts with the NOx. Spray nozzles coupled with BETE injection lances distribute the reagents evenly within the process stream to ensure proper mixing and minimize bypass.



## RECOMMENDED NOZZLES NOX REMOVAL (SCR/SCNR)



**L**  
Low Flow  
Misting Nozzle



**MicroWhirl®**  
Atomizing  
Misting Nozzle



**P**  
Fine Atomization  
Misting Nozzle



**PJ**  
Impingement  
Misting Nozzle

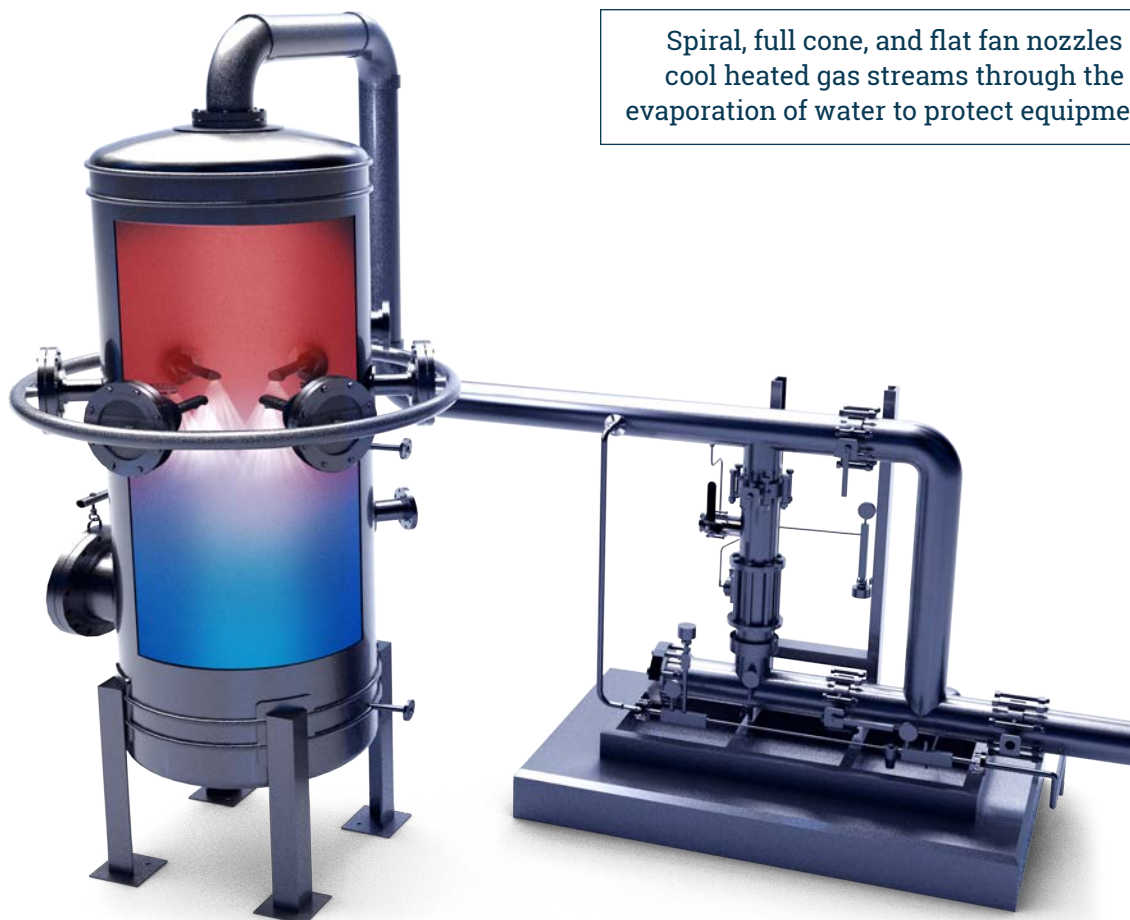


**XA**  
Low Flow  
Air Atomizing Nozzle

# GAS COOLING & CONDITIONING

BETE nozzles are used for gas cooling or quenching to create stable conditions for downstream plant components' safe and efficient operation. In many processes, gas temperatures become high enough to damage downstream equipment. The increase in temperature is caused by direct combustion, as in flue gas, or by secondary heating. The quickest, most effective way to cool a hot gas is to evaporate an injected liquid. Changing the phase of the injected fluid to gas consumes enormous amounts of energy compared to sensible/direct contact cooling.

In evaporative gas cooling, a mist of water sprays into the hot gas. In many cases, this is flue gas from a combustion process. The water then evaporates, cooling the system rapidly as the energy changes the water from liquid to gas. When a volume of water atomizes into smaller droplets, more surface area is exposed, allowing the evaporation rate to increase. The evaporation rate is critical as the gas must reach its final temperature before a fixed point downstream. The evaporation rate is mainly dependent on the droplet size, temperature differential, and partial pressure, among other variables.



BETE engineers perform detailed thermodynamic calculations to determine the ideal nozzle, droplet size, and pressure for each system. For applications with precise requirements or complex geometry, BETE offers Computational Fluid Dynamics (CFD) analysis.

## COMMON APPLICATIONS

- Cooling process gases prior to scrubber/bag-houses
- Catalyst reformer gas cooling
- Cooling combustion exhaust gases
- FGD quenching



## RECOMMENDED NOZZLES FOR GAS COOLING



**TF**  
Spiral  
Full Cone Nozzle



**TFXP**  
Clog Resistant  
Full Cone Spiral



**ST**  
Abrasion Resistant  
Full Cone Spiral



**STXP**  
Largest Free Passage  
Full Cone Spiral



**NF**  
High Impact  
Flat Fan Nozzle



**WL**  
Low Flow  
Full Cone Nozzle



**MPL**  
Low Flow  
Full Cone Nozzle



**MaxiPass®**  
Maximum Free Passage  
Full Cone Nozzle



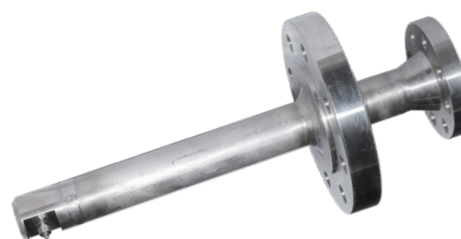
**WTZ**  
Tangential  
Full Cone Nozzle



**SC**  
Cast Metal Alloy  
Full Cone Nozzle

## SPRAY LANCES AND HEADERS FOR GAS COOLING

BETE can design and fabricate a spray lance solution to efficiently cool a process stream, even in high-temperature environments. For spray distribution over a large area, multiple nozzles on headers or manifolds offer an effective solution.





# TANK CLEANING

Tank cleaning is essential, especially when removing harsh chemicals and soils, which can be time-consuming and expensive without the correct solution. Storage tanks, process vessels, and reactors can vary significantly in size and shape across the chemical industry.

Almost all tanks require cleaning before and after each use to ensure sanitary conditions and prevent batch contamination. BETE offers a complete line of tank cleaning nozzles to help maximize efficiency. When choosing a suitable device, there are three different design types available. Our spray experts can analyze your application to recommend the ideal solution for your process conditions.



Stationary and rotational tank cleaning nozzles remove residue and ensure all interior surfaces of the tank are clean.

# TYPES OF TANK CLEANING NOZZLES

## STATIONARY

Stationary nozzles, also known as static nozzles, have no moving parts. These tank cleaning nozzles are low-maintenance designs, which provide sizable free passage superior to other products on the market.



**HydroClaw®**



**TW  
Spiral**

## REACTIONARY FORCE

Fluid-driven tank cleaning nozzles use the reaction force of the spray media to drive the rotation of the nozzle head. These provide complete 360° coverage and efficient cleaning through impact and repetition. Rotating nozzles ensure a significant increase in tank cleaning efficiency over static spray balls, saving time and money by reducing water and cleaning agent consumption while decreasing downtime.



**HydroWhirl® S**



**HydroWhirl®  
Poseidon**

## ROTARY JET

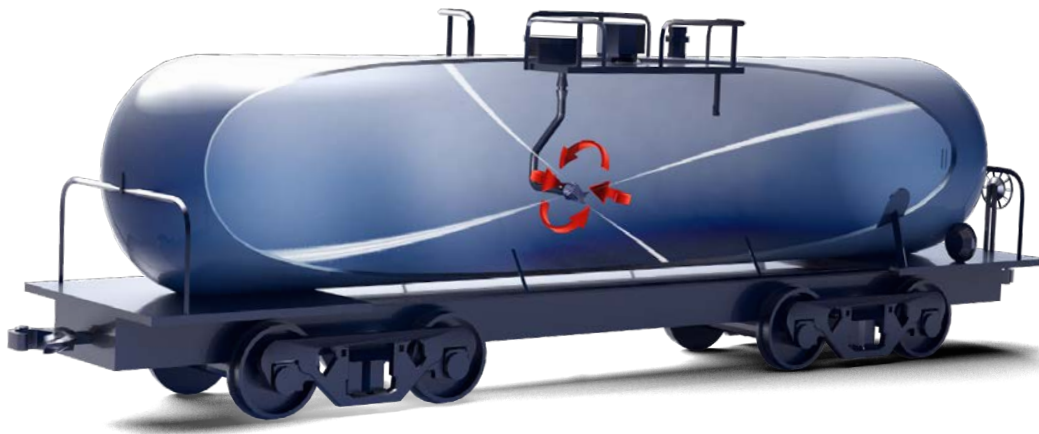
Tank cleaning machines use the spray media flowing through internal gears on the body to rotate sets of high-impact jet nozzles through an efficient 2-axis orbital pattern, providing complete 360° coverage. The jet pattern nozzles utilized on these assemblies provide significantly more impact and impingement force than other styles of tank cleaning nozzles, making them ideal for hard-to-clean residues and larger vessels.



**HydroWhirl®  
Orbitor**



**HydroWhirl®  
Orbitor 100**



# FIRE PROTECTION

BETE fire protection nozzles are recognized across the petroleum and chemical processing industries as the first choice in dry, fixed fire suppression systems. BETE nozzles are used routinely in dry fire protection systems protecting offshore drilling rigs, LPG tanks, and LNG tanks, as well as other types of vessels containing flammable liquids.

## WATER DELUGE SPRAY SOLUTIONS

There are two general categories for water deluge types of fire protection systems.

### Cooling

- Water sprays onto the exterior surface of vessels that are under pressure and may contain volatile materials. The water keeps the contents cool, thereby preventing the contents from increasing in pressure. Commonly used in tank farms and vessels where catastrophic failure might occur from overheating.

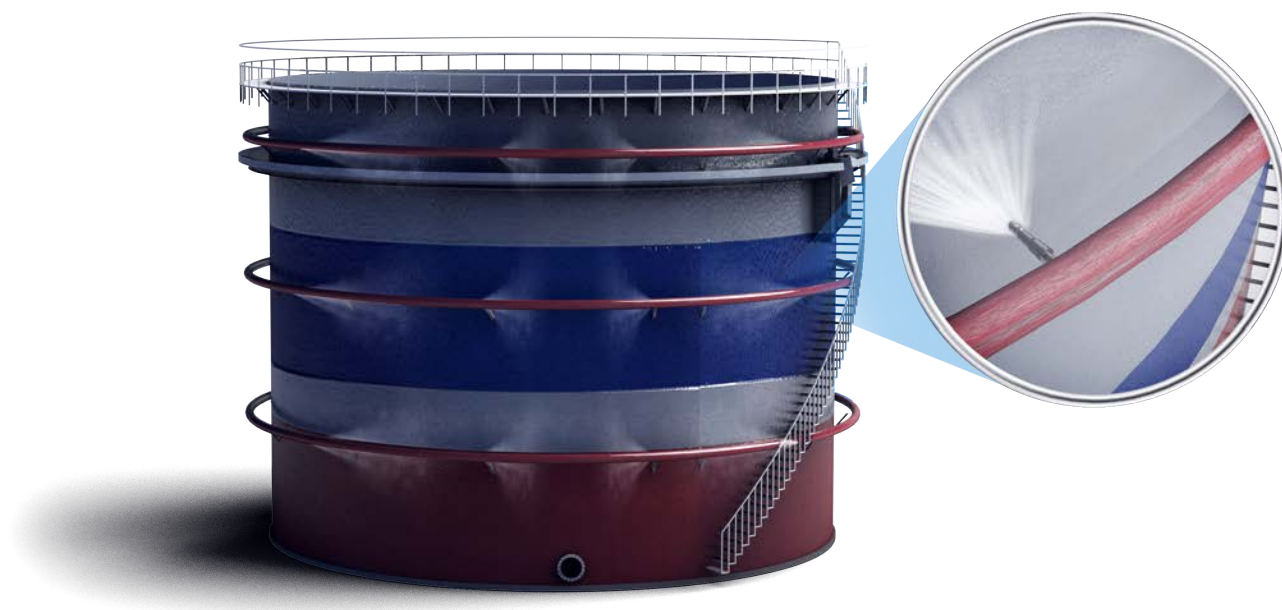


## Wetting

- Water sprays to control the spread of a fire but not extinguish it. Wetting is a standard solution for gas leak situations where the gas continues to be consumed by the flame until someone can turn off the gas flow. Extinguishing these types of fires before turning off the gas flow can cause a dangerous build-up of flammable gas that may lead to an explosion.

## WATER WALL SPRAY SOLUTIONS

A water wall is a spray of water that acts as a barrier to shield personnel and equipment against radiant heat, harmful gases, and flames. The more water sprayed to form the suppression wall, the better the fire protection and shielding. High pressure and flow rates project water faster and farther to create a larger buffer between the heat source and the protected areas.



## RECOMMENDED NOZZLES FOR FIRE PROTECTION



**AFF**  
FM Approved  
Flat Fan Nozzle



**N**  
FM & UL Approved  
Full Cone Spiral



**TF29-180**  
Ultra-Wide  
Full Cone Spiral





# CHOOSE THE RIGHT PARTNER FOR YOUR SPRAY REQUIREMENTS

Understanding nozzle performance and how a spray behaves in your chemical process is critical. Every phase from design and manufacturing to testing and quality assurance is performed in-house, ensuring close coordination through each stage to meet all mechanical and performance requirements.

## MANUFACTURING SERVICES

Our state-of-the-art manufacturing facility utilizes various manufacturing processes to produce standard or custom nozzles and tailored spraying solutions for specific application requirements. We attribute the driving force behind all of this to our highly qualified employees. They respond to the needs of our customers – ensuring that performance, quality, and delivery expectations are all met.

Investment casting offers a precise and economical way to produce complex shapes in alloys that are difficult or expensive to machine.

BETE is the only nozzle manufacturer with an in-house casting foundry, with various alloys on hand that offer excellent corrosion and abrasion resistance properties. Our engineers can help you select materials for maximum effectiveness and operating life in your spray application.



# SPRAY FABRICATION SERVICES

Among a long list of industries, chemical plants have counted on BETE's nozzle engineering expertise for decades to supply fabricated spray assemblies designed from the nozzle up. Starting with the process conditions, we recommend the most appropriate nozzle and incorporate it into a fabricated injector, lance, quill, spool, header, or manifold.

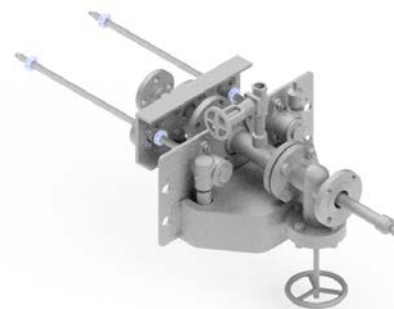
Working with BETE as your primary fabricator ensures all components fit and work together seamlessly. Our welding department, which is fully qualified to ASME B & PV Code Section IX, has made a specialty of joining dissimilar metals. Their expertise makes it possible to design nozzles and assemblies combining alloys with superior anti-abrasion or corrosion properties.

## COMMON DESIGN REQUIREMENTS

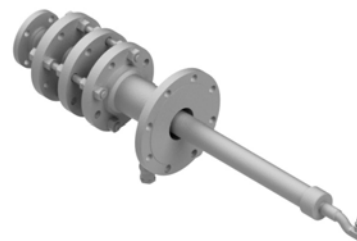
- ASME B31.3 – Process Piping
- ASME B31.1 – Power Piping (PP Authorization)
- ASME Boiler and Pressure Vessel Code Section VIII Division 1 (U Authorization)
- Welding qualification to ASME B&PVC Section IX
- Canadian Registration (CRN)
- Pressure Equipment Directive (PED) 2014/68/EU
- NACE Compliance

## TESTING & VALIDATION

BETE's integrated engineering, quality, and manufacturing departments combine to meet virtually any code, testing, or inspection requirement.



**Retractable Lance with Mechanism**



**Lance with Inlet Valve**



**Ring Header**



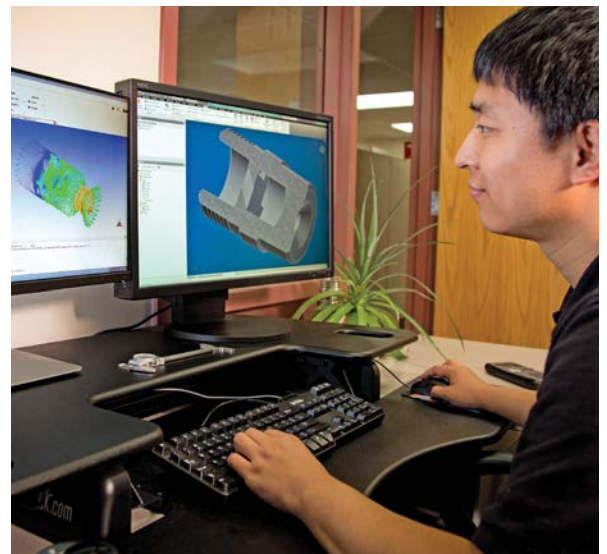
# ENGINEERING SERVICES

## APPLICATIONS ENGINEERING

BETE Applications Engineers can assist you when your application requires a custom-designed nozzle, involves precise spray performance, or unusual operating conditions. Our engineers have decades of combined experience in nozzle design and process specification.

## DESIGN ENGINEERING

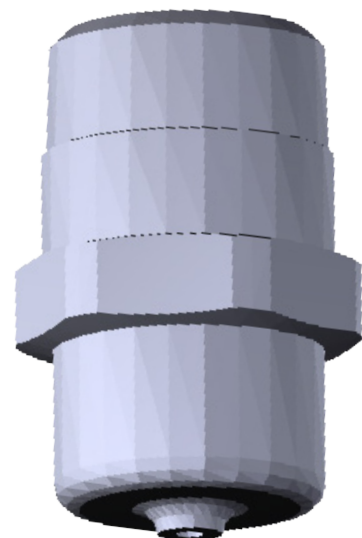
BETE's advanced CIM (Computer Integrated Manufacturing) environment links our in-house design engineering team's CAD workstations with a CAM part programming system, and CNC machine tools. The spray engineering group works with our manufacturing and design engineering teams to help you design your process or solve your spray problem. Through cross-department collaboration, we ensure that the result is manufacturable and cost-effective.



## 3D CAD MODELS

Accelerate your design time and improve engineering accuracy with our free, on-demand 3D CAD solid models configuration available on our website for select nozzle series.

Choose from over 100 CAD formats and versions to download a 3D spray nozzle and virtually test it within your design.



# ADVANCED SPRAY ENGINEERING SERVICES

We offer Advanced Spray Engineering Services (ASES) to solve more challenging and critical problems, including the ability to do CFD studies and physical testing. At each stage of a contracted project, we work with you to ensure we're solving the right problem within the given constraints.

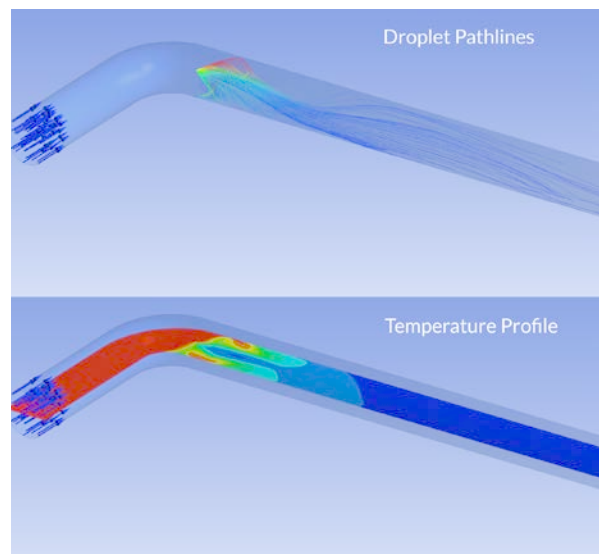
## SPRAY LABORATORY SERVICES, TESTING, AND MODELING

Through specialized testing and analysis, we can help improve efficiency and cut fluid process costs.

- Droplet Size Analysis
- Spray Pattern Analysis
- Design of Experiments
- Physical Modeling

## COMPUTER MODELING

BETE offers computer modeling of sprays and processes using ANSYS® FLUENT® computational fluid dynamics software (CFD). Modeling of a spray process can be very helpful in selecting nozzles, operating conditions, and mounting locations when initially designing a process, especially if the process is not amenable to physical testing. It can also help find the cause of problems in an existing operation.







# COMPLETE SPRAY SYSTEM SOLUTIONS

BETE's deep understanding of spray nozzle system performance allows us to design and build custom-tailored flow control systems to meet your specific spray process needs and precision operations.

We evaluate your existing process or new project requirements and recommend solutions to achieve performance and reliability. Optimizations for preexisting systems can address pressure loss caused by pipe friction, elevation, and valve or instrument flow coefficients.



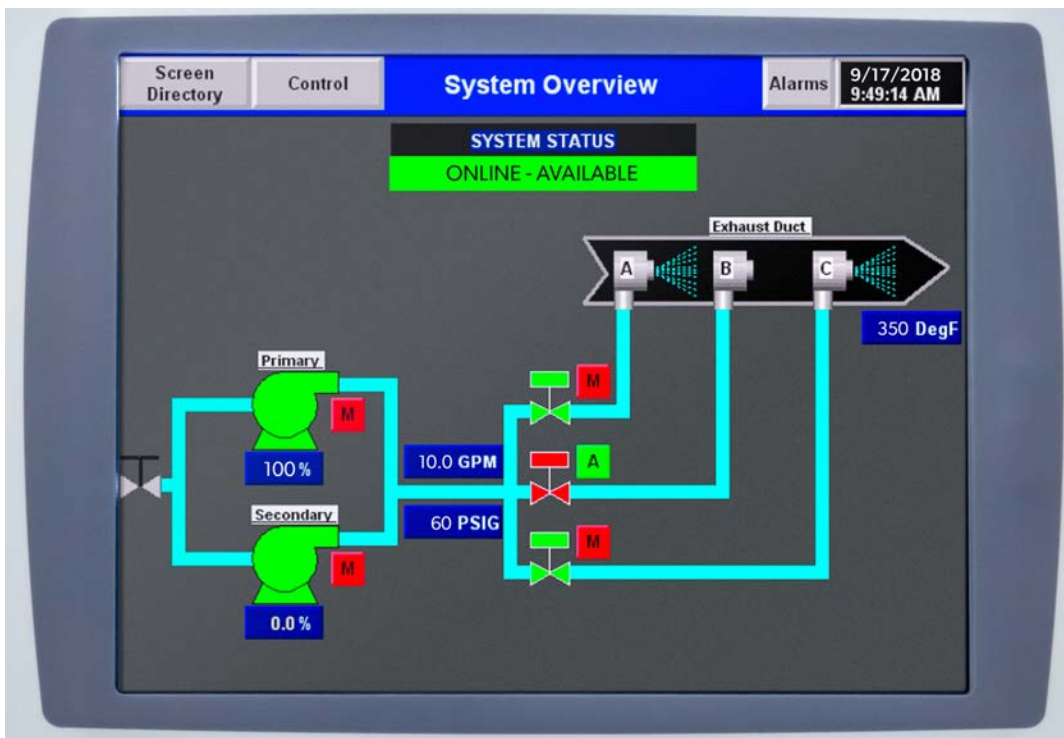
The custom control panel of this bespoke Gas Cooling System monitors downstream gas temperature and adjusts water flow rate to maintain a target outlet condition. The customer contracted a CFD study to determine precise flow rate and drop size for effective cooling and complete evaporation.

## PERFORMANCE SPRAY ENGINEERING: THE WHOLE PACKAGE

When it comes to providing high quality spray performance, selection of an appropriate spray nozzle model is only the first step in successful implementation. It's important that all aspects of the flow control system be properly sized based on the target spray parameters.

We prioritize the engineering of upstream flow control equipment, including pump and flow control skids, to ensure that nozzles are supplied with the proper fluid conditions to function as intended.

Contact us today to see how our trusted industry experience and automated spray solutions can help you increase the performance, reliability, efficiency, and profitability of your spray process.



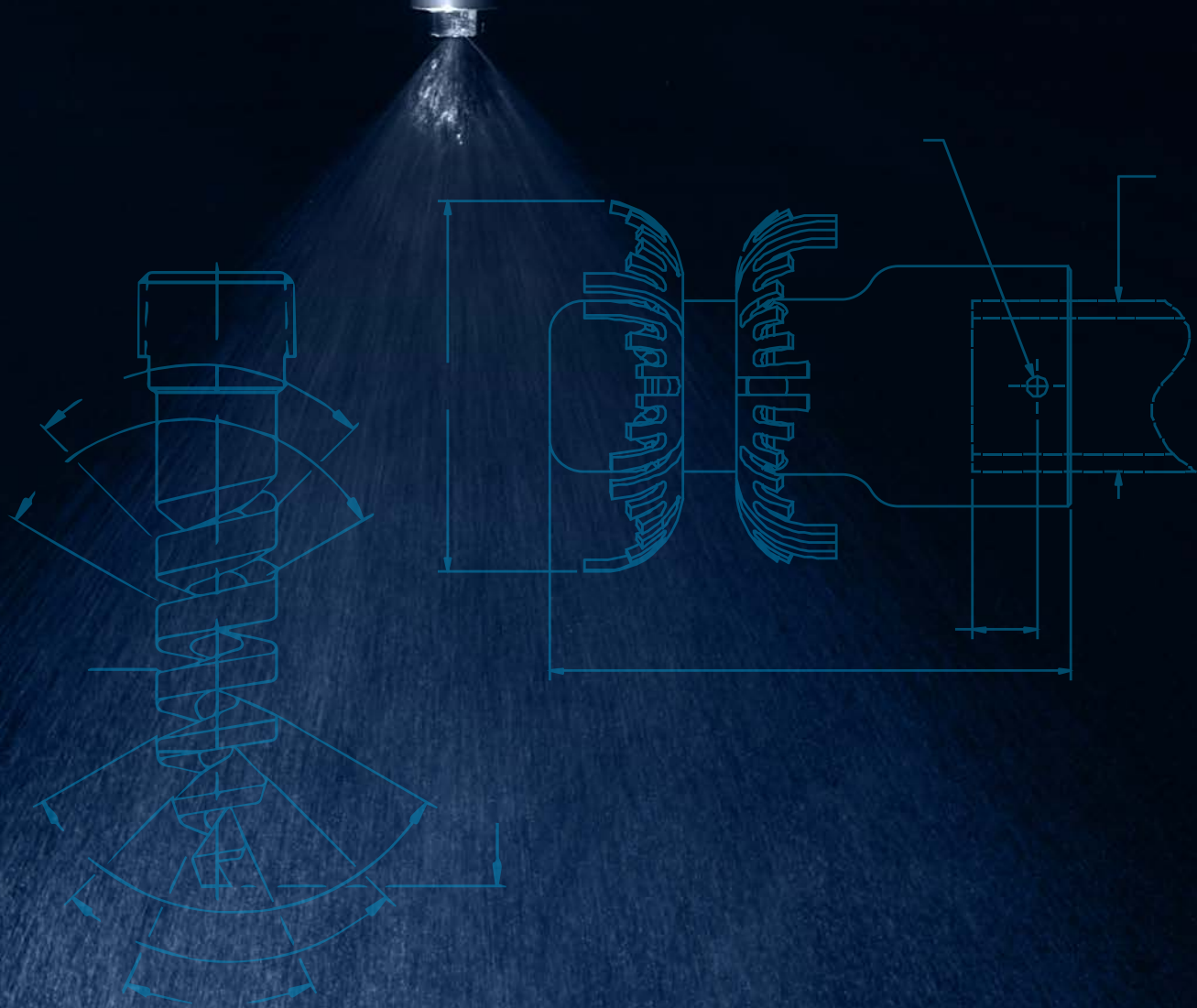
## ADVANTAGES OF BETE SPRAYING SYSTEMS

- Operate as stand-alone units or integrate with central plant control systems
- System designs target spray parameters to improve performance, reliability, and profitability
- Close coordination through all phases of the process
- Extensive engineering and manufacturing resources under one roof

## COMPONENTS FOR ENGINEERED SPRAY SYSTEMS

- Nozzles/Lances
- Piping/Tubing/Fittings
- Valves
- Pressure Regulators
- Strainers/Filters
- Solenoids
- Automatic Control Valves
- Pumps/Motors
- Pressure/Temperature/Flow Sensors
- Variable Frequency Drives (VFD)
- Programmable Logic Controllers (PLC)
- Switches, Relays, and other Electrical Hardware
- Structural Skid Frames





BETE Fog Nozzle, Inc.

50 Greenfield Street, Greenfield | MA 01301 USA

413-772-0846 | [www.BETE.com](http://www.BETE.com) | [sales@BETE.com](mailto:sales@BETE.com)



Spray  
Nozzles



Spray  
Fabrications



Spray  
Systems



Applications  
Engineering



Spray  
Research