Optimizing Spray Injector Performance in Petroleum Refining
Spray injectors, sometimes referred to as quills or lances, are widely used in every refinery. With the demand for refined product rising, so is the demand for spray injectors as petroleum producers embark on upgrade/expansion projects and new construction. Spray injectors are often viewed as simple devices that deliver fluid or gas to the nozzle prior to injection. However, spray injectors can have a significant impact on the performance of the entire spray system and should be given careful consideration during design and fabrication.

Optimizing spray injector performance requires an extensive knowledge of spray technology. And that’s where we come in. We work with leading engineering firms and oil companies around the world to design and build durable, dependable, low maintenance injectors that deliver the required performance be it in the FCCU riser, catalyst regenerator, coker, pollution control equipment or other areas of the refinery.

In the pages that follow, you’ll learn more about spray technology, key design considerations for spray injectors and ways to optimize performance. While these general guidelines should prove helpful, please contact us to discuss your application. Spray injectors are designed to match physical spaces, the operating environment and performance requirements.
Key Factors in Spray Injector Design and Performance

Size of duct, vessel, tower
• Impacts the size of the injector, number of nozzles, spray pattern, spray angle, placement of nozzles and drop size/residence time of the spray

Bends, miters and elbows in ducts
• Impacts flow profiles, placement of injectors to avoid erosion of process equipment and wall wetting

Proximity to upstream or downstream equipment
• Impacts spray plume shape, pattern and velocity

Operating conditions such as gas and liquid properties, temperature, corrosiveness
• Impacts materials of construction, coatings, spray distance

Liquid composition
• Impacts materials of construction, spray pattern, maximum free passage

Fluid service category
• Impacts safety design requirements per ASME® and other construction codes

Co-current or counter-current sprays
• Impacts residence times, drop size, spray angles, build-up, vibration, stress

Connection types
• Impacts safety, other design standards, current field connections

Physical restrictions on injector placement
• Impacts flexible or rigid design, weight limitations

Service life requirements
• Impacts materials of construction, design requirements

Maintenance requirements
• Impacts design features such as mechanical retraction devices
Injector Solutions

Refinery injectors need to meet exacting performance requirements. And to achieve those performance goals, injector designs are typically complex, comply with extreme engineering standards for safety and necessitate the use of special materials and coatings to withstand harsh environments. While each injector is unique, there are many common design attributes. (See chart to right.)

A. Defoaming Injectors
These injectors are used to uniformly disperse defoaming agents into the process stream or onto a surface.

B. Distillation Column Injectors
Water wash injections, typically continuous and low volume, are used to avoid salt build-up or reduce corrosiveness in the distillation column overheads.

C. FCCU Overhead Water Wash Injectors
Used to minimize corrosion, cracking or hydrogen blistering from exposure to ammonia and cyanide, these devices inject water wash or corrosion inhibitors into ductwork above the FCCU.

D. FCCU Feed Injectors
Fresh feed is injected into catalyst-laden gas stream in the FCCU to atomize the feed for best cracking. These injectors are designed to operate for several years without maintenance.

E. Steam Quench Injectors
Light cycle oil is injected into the gas stream prior to entry into a cracking or reforming heater to lower temperature and stop the cracking process.

F. Slurry Backflush Injectors
Hydrocarbons entrained with catalyst are re-injected into the FCCU via robust, wear resistant injectors.

G. Packed Tower Headers
Injectors distribute fluid evenly to thoroughly clean packing material.

H. Heat Exchanger Injectors
To prevent corrosion problems, glycol or other inhibitors are injected onto the ends of heat exchanger tubes.

I. Additive Injectors
Small volumes of chemicals, inhibitors and/or detergents are injected into petroleum products to improve quality or add special characteristics.

J. Mix Temperature Control (MTC) Injectors
Positioned above the fresh feed injectors in the riser, these injectors are used to control riser outlet temperature. Light cycle oil is injected on a continuous basis.

K. Torch Oil Injectors
For heat during start-up, shutdown, or feed-outage conditions, liquid oil is injected and burned in FCC regenerators.

L. Regenerator Bypass Injectors
When the waste heat steam generator is offline, these injectors are used to cool gases prior to SCR NOx reduction equipment.

M. Catalyst Reformer Gas Cooling Injectors
Injectors are used to cool the exterior of the catalytic reformers to control temperature.

N. Chloride Injectors
Used for propylene dichloride and alcohol injection into naphtha feed line for corrosion resistance.

O. Fractionator Water Wash Injectors
Water wash injections, typically continuous and low volume, are used to avoid salt build-up or reduce corrosiveness in the fractionator overheads.

P. Coker Off-Gas Cooling Injectors
Steam atomizing injectors are used to cool coker gas with 100% evaporation prior to entry to downstream particulate collection devices.

Q. Flue Gas Desulfurization Injectors
Injectors equipped with clog-resistant nozzles constructed of silicon carbide or other ceramic materials are used to neutralize gas or liquid in a tower.

R. SNCR NOx Control Injectors
Injection of aqueous ammonia is used to act as a reagent and mix with molecular NOx at high temperatures to reduce NOx emissions.

S. SCR NOx Control Injectors
Injection of aqueous ammonia is used to act as a reagent and mix with molecular NOx at high temperatures to reduce NOx emissions.

T. Desuperheating Injectors
Injection of a fine spray of feed water into superheated steam provides cooling so the steam can be used in lower pressure processes downstream.

The list below and illustration to the right show some of the more the common applications in refineries where spray injectors are used. There are many others so be sure to contact us for additional information. We have wide ranging experience with dozens of different injector types for dozens of refinery operations.
## Injector Type

<table>
<thead>
<tr>
<th>Injector Type</th>
<th>Key Design Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defoaming</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Distillation Column</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>FCCC Overhead Water Wash</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>FCCC Feed Injector</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Steam Quench Injector</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Slurry Backflush Injector</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Packed Tower Headers</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Heat Exchanger Bundle Sprays</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Additive Injection</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Mix Temperature Control</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Torch Oil</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Regenerator Bypass</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Catalyst Reformer Gas Cooling</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Chloride Injection</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Fractionator Water Wash Injection</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Coker Off-Gas Cooling</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Flue Gas Desulfurization</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>SNCR NOx Control</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>SCR NOx Control</strong></td>
<td>X</td>
</tr>
<tr>
<td><strong>Desuperheating</strong></td>
<td>X</td>
</tr>
</tbody>
</table>

- **Flat Fan Pattern:** X
- **Full Cone Pattern:** X
- **Molten Cone Pattern:** X
- **Gas Atomizing Fine Spray:** X
- **Hydraulic Atomizing Fine Spray:** X
- **Wear Resistant Materials:** X
- **High Pressure:** X
- **High Temperature Alloys:** X
- **Corrosion Resistant Materials:** X
- **Tight Drop Size Distribution:** X
To Downstream Processes
(Not Shown)
Use of Computational Fluid Dynamics Ensures Optimal Performance

**Our Credentials**

**Engineering:**
- Decades of experience with a sole focus on spray technology
- Engineering specialists, Professional Engineers (PE), piping and welding experts
- Spray characterization in our fully equipped spray laboratory to simulate injector operating conditions. Typical tests include:
  - Drop size and distribution
  - Gas velocity and density
- Computational Fluid Dynamics (CFD)
  - CFD and proprietary drop distribution functions allow determination of injector performance when operating conditions cannot be simulated
  - Ensures optimal nozzle placement, spray pattern type and angle

**Manufacturing:**
- ASME® Boiler and Pressure Vessel Code
- ASME B31.1 Power Piping Code
- ASME B31.3 Process Piping Code
- Welding to ASME B&PV Code Section IX
- Canadian Registration Number requirements

**Testing in accordance with ANSI®, ASTM® standards:**
- Ultrasonic
- Radiographic
- Liquid penetrant
- Hardness
- Hydrostatic
- Magnetic particle examination
- Positive material identification

References available upon request.

ASME® is a registered trademark of American Society of Mechanical Engineers (ASME, ASME International).

ASTM® is a registered trademark of ASTM International.

ANSI® is a registered trademark of the American National Standards Institute.

**Spraying Systems Co.**
Experts in Spray Technology

North Avenue and Schmale Road, P.O. Box 7900, Wheaton, IL 60187-7901 USA

Tel: 1.800.95.SPRAY  Intl. Tel: 1.630.665.5000
Fax: 1.888.95.SPRAY  Intl. Fax: 1.630.260.0842
www.spray.com

Bulletin No. 617A Printed in the U.S.A. ©Spraying Systems Co. 2011