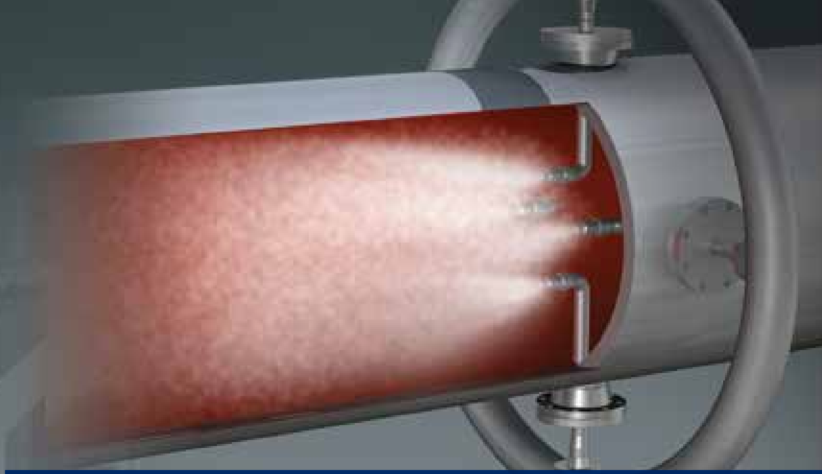
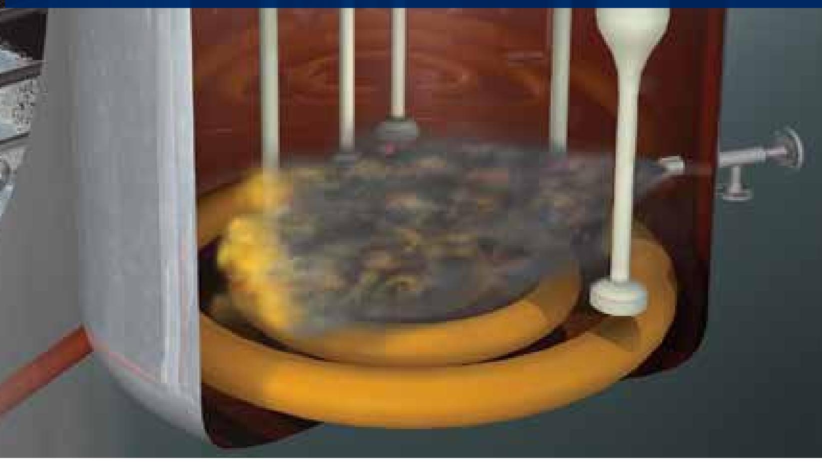



BEST PRACTICES FOR REFINERIES

WASHING, INJECTION, COOLING & QUENCHING OPERATIONS

Spraying Systems Co.®
Experts in Spray Technology




PERFORMANCE OPTIMIZATION INSIDE PIPES, OVERHEAD LINES, VESSELS & MORE

When equipment is going to be installed inside of piping or another vessel, it is essential that it is designed properly for the application, can withstand the operating environment and delivers the required performance and service life. Once that piece of equipment is installed, it's out of sight and often, out of mind. Performance problems are hard to detect until degradation is severe. Unscheduled shutdowns to address performance issues are costly and disruptive.

That's why it is essential to understand:

- Which type of equipment is best for the operation – washing, cooling, injecting, quenching or humidifying
- Where the equipment should be placed in the process stream
- Fabrication requirements to ensure long service life
- Actual performance with your process conditions prior to construction and installation

Partnering with Spraying Systems Co. will help ensure predictable, repeatable performance in the CDU, FCCU, hydrotreater, coker and more to avoid problems like these:

- Wall wetting
- Duct corrosion
- Refractory cracking
- Damage to downstream equipment
- Premature equipment failure

We have the expertise and experience needed to design, fabricate and validate performance:

- Code-compliant manufacturing
- Modeling and testing services
- Proven track record with leading refineries and engineering firms around the world
- 80+ years of spray technology experience
- Refinery specialists, research engineers and dedicated manufacturing resources

Spray Quill

Spray Injector

IT ALL STARTS WITH THE NOZZLE

If you're using spray quills – pipes with slits or holes – your process efficiency is compromised. The fluid exiting the pipe is uninhibited. A spray injector – pipes with one or more nozzles – corrects this problem. The nozzle converts the fluid exiting the pipe into a predictable drop size spectrum with specific spray characteristics. This means there is more control over the distribution of the fluid in the receiving process stream resulting in:

- More thorough washing of gas
- More efficient cooling of vapors
- Increased efficiency of SO_2 removal
- Improved scrubber efficiency
- Reduced wall impingement

Nozzle selection is an important first step. But it is just the beginning. In the pages that follow, you'll find additional information and recommended best practices for optimizing performance and improving sustainability in several refinery operations. When you're ready to increase efficiency, boost production and reduce chemical waste, product loss and equipment failure, give us a call and tap into our unmatched expertise and capabilities. **We're standing by and ready to help. 1.800.95.SPRAY or visit www.spray.com**

TABLE OF CONTENTS

CRUDE DISTILLATION UNIT (CDU)

1. WATER WASH

Problem: Effective wash injection to dilute acid that has formed in the liquid phase and dissolve salt deposits.

Best practice: Use spray injectors instead of quills to minimize the risk of excess free water that may not interact properly with the vapor stream and cause erosion and other corrosion issues. Instead of using flow rate and pressure drop to determine injection points, use Computational Fluid Dynamics (CFD) to validate performance prior to finalizing injector design.

2. FILMING CORROSION INHIBITOR

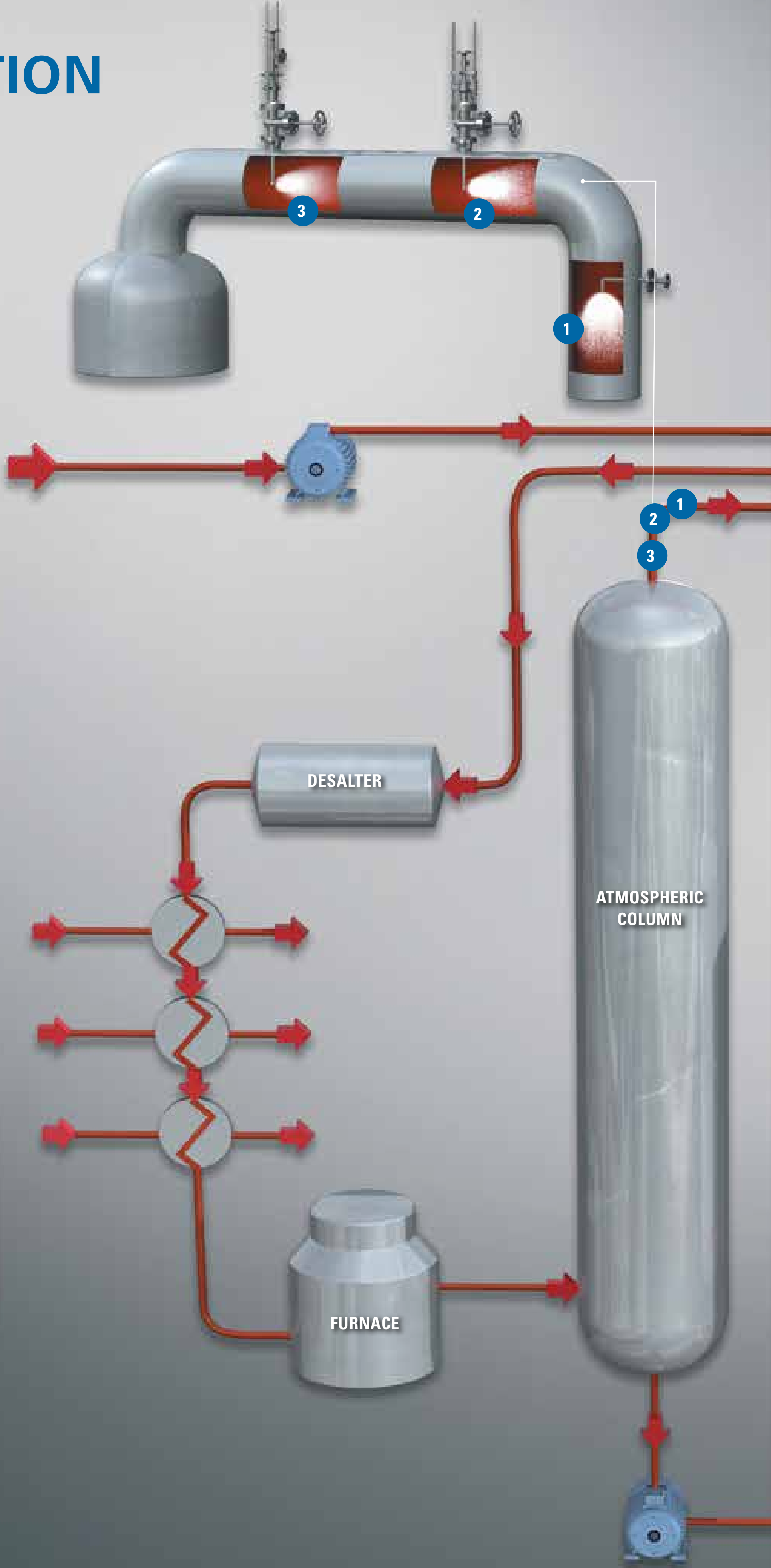
Problem: Creating a protective film barrier on the inside of the overhead line.

Best practice: Use WhirlJet® hollow cone spray nozzles spraying at low flow rates and operating at lower pressures to maximize drop size and filming effectiveness. The hollow cone spray pattern effectively applies the filmer to pipe wall.

3. NEUTRALIZING AMINE

Problem: Wasted chemical and possible corrosion on overhead piping caused by ineffective neutralizer injection.

Best practice: Use spray injectors designed to use steam as the atomizing fluid. This is preferable to feeding the neutralizer and steam through a quill. A steam atomized retractable injector ensures none of the neutralizer remains in a liquid state and provides more effective HCl neutralization.



4. FIN FAN WATER WASH

Problem: Poor wash water distribution and pooling on the floor of the header box.

Best practice: Position the spray nozzles inside the header box or install individual spray nozzles at pre-determined locations using clean-out plugs. Also, use Computational Fluid Dynamics (CFD) to validate performance before beginning injector design. Spray injector performance will vary greatly depending on gas flow rate and velocity. CFD can determine optimal spray nozzle placement.

5. OVERHEAD WATER WASH

Problem: Corrosion and salt in the overhead line and downstream equipment.

Best practice: Continuous wash water injection to prevent or remove corrosive build-up. Injectors equipped with WhirlJet® hollow cone and FullJet® full cone spray nozzles are widely used. The nozzles produce small- to medium-sized drops and uniform coverage. Also, use CFD to determine the optimal dispersion, coverage and injector placement for corrosion prevention.

6. VGO WASH BED SPRAY HEADER

Problem: Prevent dry zones in the wash bed that produce coke formation and result in higher pressure drops in the column.

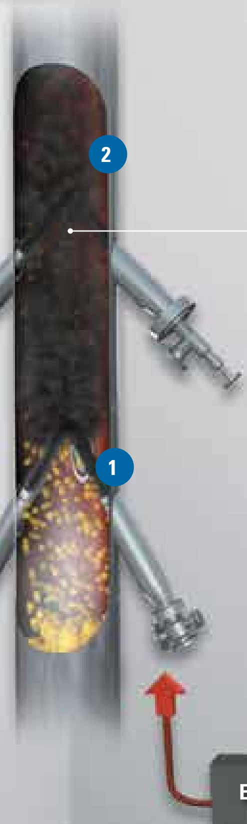
Best practice: Maximum Free Passage (MFP) FullJet full cone nozzles with wide spray angles maximize coverage and overlap to ensure uniform wetting. MFP FullJet nozzles produce large droplets at lower operating pressures than other nozzles. In addition, large flow passages prevent nozzle clogging and reduce maintenance downtime.

FLUID CATALYTIC CRACKING UNIT (FCCU)

1. FRESH FEED

Problem: Maximize yield when injecting feed oil.

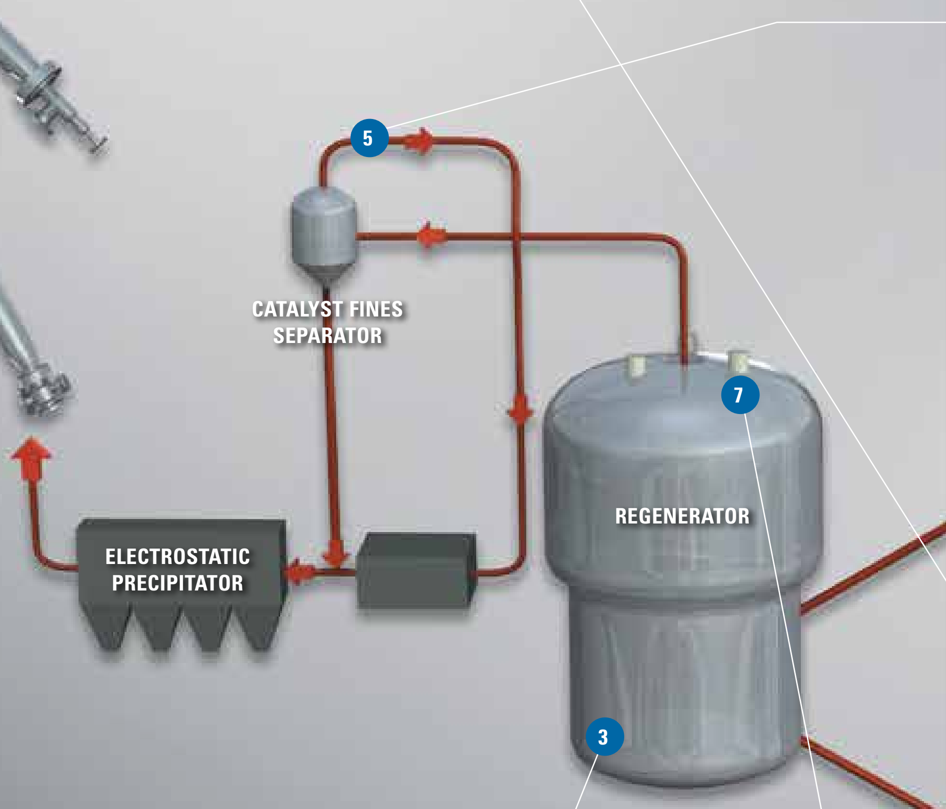
Best practice: Leading providers of FCCU riser technology supply proprietary feed injection systems with nozzles designed specifically for superior feed stock injection and extended wear life. These systems deliver the optimal drop size and spray distribution to increase cracking efficiency and yield.



2. BIO-OIL INJECTION

Problem: Inconsistent performance and reduced yield caused by nozzle wear.

Best practice: Use injectors that allow adjustment of feed rates, prevent feed polymerization and feature specially-designed wear-resistant nozzles.



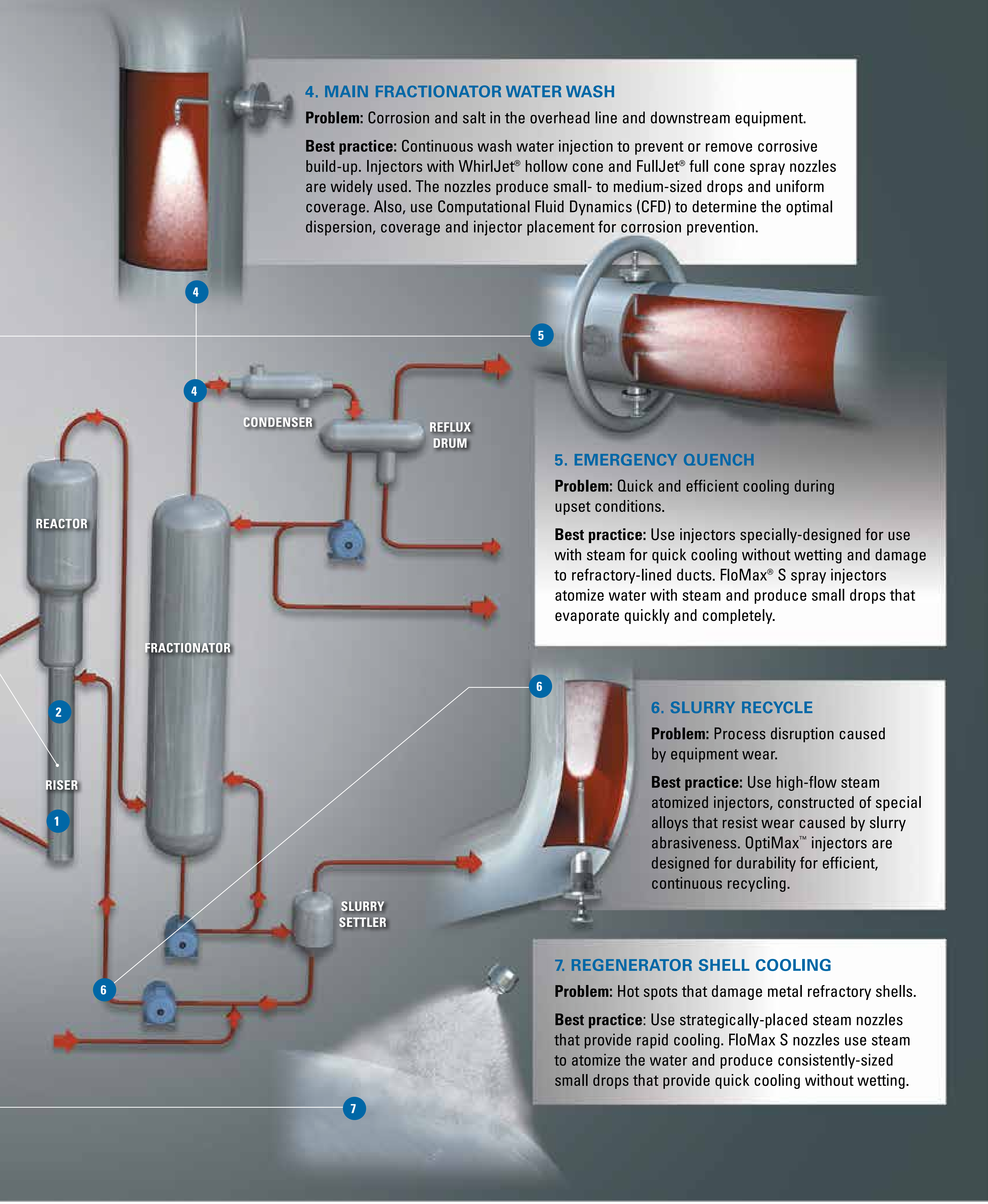
3. TORCH OIL

Problem: Safety issues such as CO_2 build-up, mechanical issues in the regenerator during start-up and feed outage conditions caused by incomplete torch oil combustion.

Best practice: Use OptiMax™ injectors with patented technology for thorough mixing of the oil and steam. The injector produces uniformly sized small drops and consistent spray coverage to ensure complete combustion.

INJECTORS ARE ALSO AVAILABLE FOR:

- Gas scrubbing
- NOx control



4. MAIN FRACTIONATOR WATER WASH

Problem: Corrosion and salt in the overhead line and downstream equipment.

Best practice: Continuous wash water injection to prevent or remove corrosive build-up. Injectors with WhirlJet® hollow cone and FullJet® full cone spray nozzles are widely used. The nozzles produce small- to medium-sized drops and uniform coverage. Also, use Computational Fluid Dynamics (CFD) to determine the optimal dispersion, coverage and injector placement for corrosion prevention.

5. EMERGENCY QUENCH

Problem: Quick and efficient cooling during upset conditions.

Best practice: Use injectors specially-designed for use with steam for quick cooling without wetting and damage to refractory-lined ducts. FloMax® S spray injectors atomize water with steam and produce small drops that evaporate quickly and completely.

6. SLURRY RECYCLE

Problem: Process disruption caused by equipment wear.

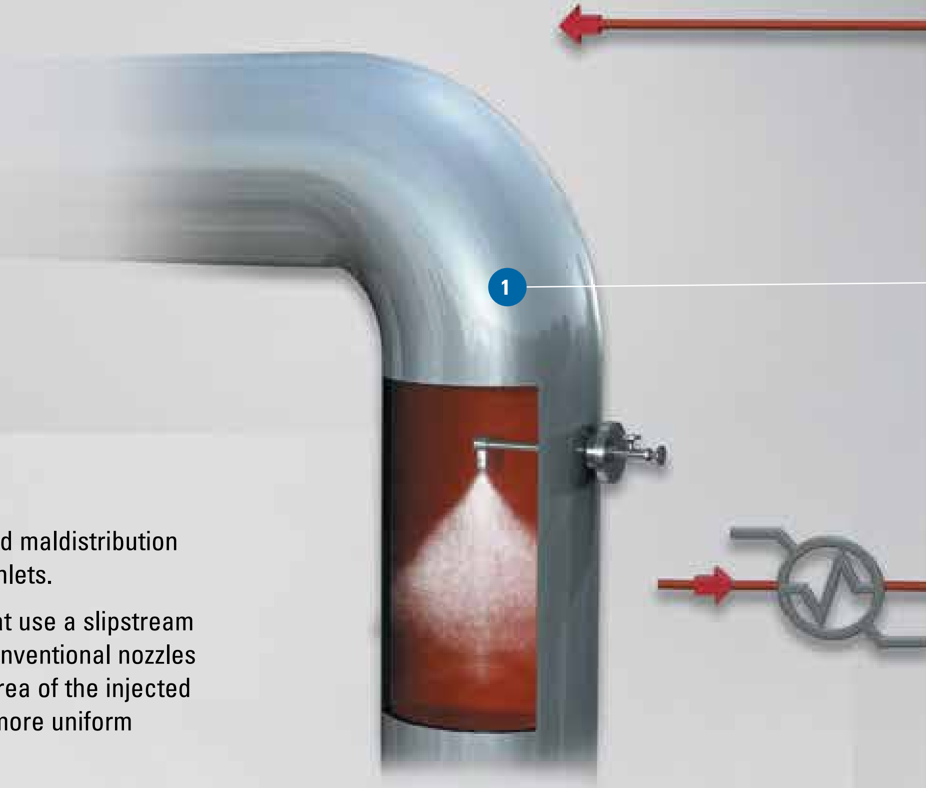
Best practice: Use high-flow steam atomized injectors, constructed of special alloys that resist wear caused by slurry abrasiveness. OptiMax™ injectors are designed for durability for efficient, continuous recycling.

7. REGENERATOR SHELL COOLING

Problem: Hot spots that damage metal refractory shells.

Best practice: Use strategically-placed steam nozzles that provide rapid cooling. FloMax S nozzles use steam to atomize the water and produce consistently-sized small drops that provide quick cooling without wetting.

HYDROTREATER



1. WATER WASH

Problem: Inadequate chloride scrubbing, wall wetting and maldistribution of the wash water through the piping system and REAC inlets.

Best Practice: Use FloMax® H two-fluid spray nozzles that use a slipstream of makeup hydrogen as the secondary fluid instead of conventional nozzles or spray quills. FloMax H nozzles maximize the surface area of the injected water and enable better contact with the chlorides and more uniform distribution of the wash water.

THE DIFFERENCES EXPLAINED

QUILL

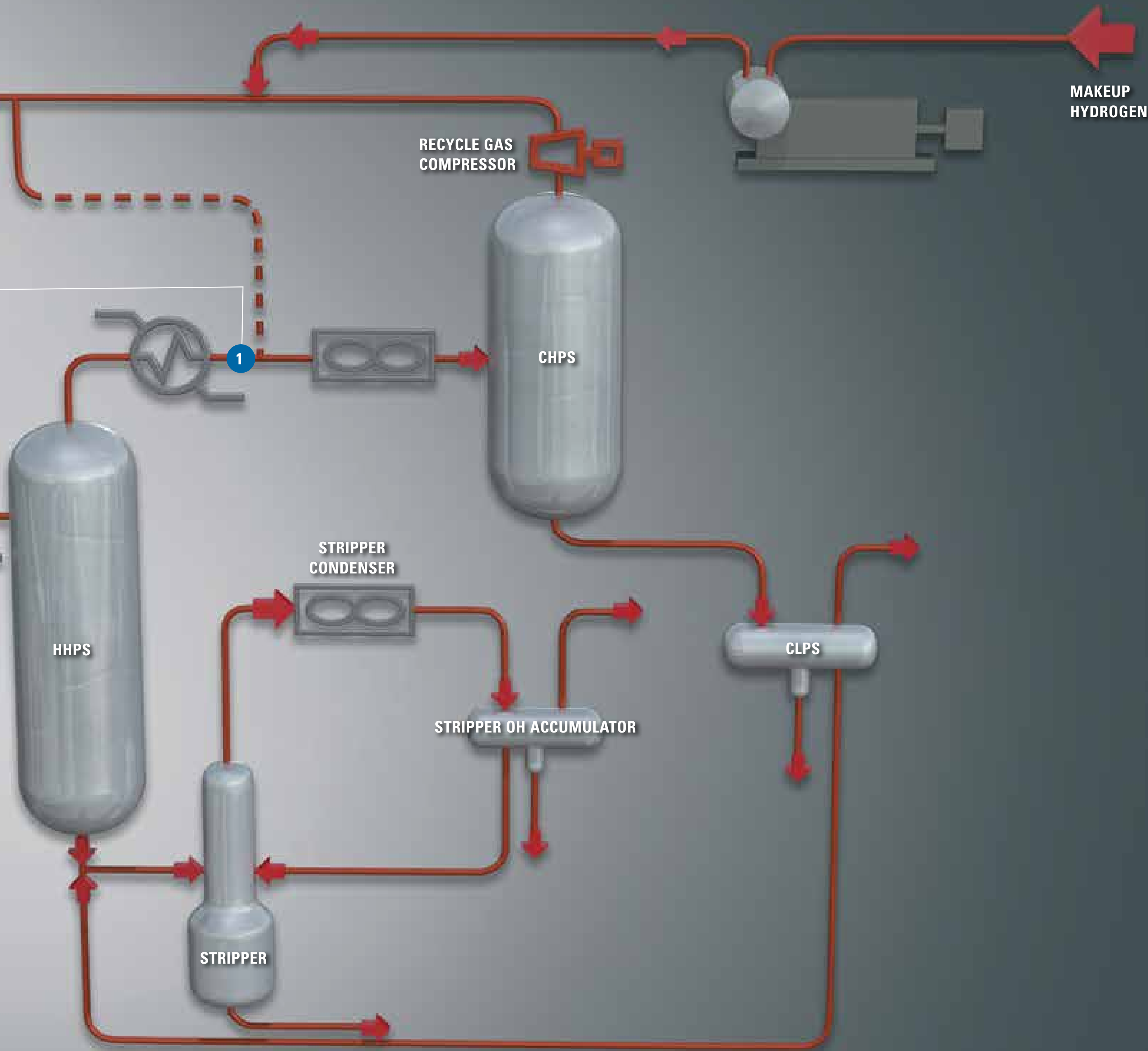
Quills used for water wash in hydroprocessing units typically have rectangular orifices that don't form discrete droplets. This results in minimal surface area for chloride scrubbing. In addition, the wash water isn't distributed uniformly and salt downstream of the injection point may not be dissolved. In some cases, this maldistribution of wash water may encourage salt formation.

HYDRAULIC SPRAY NOZZLE

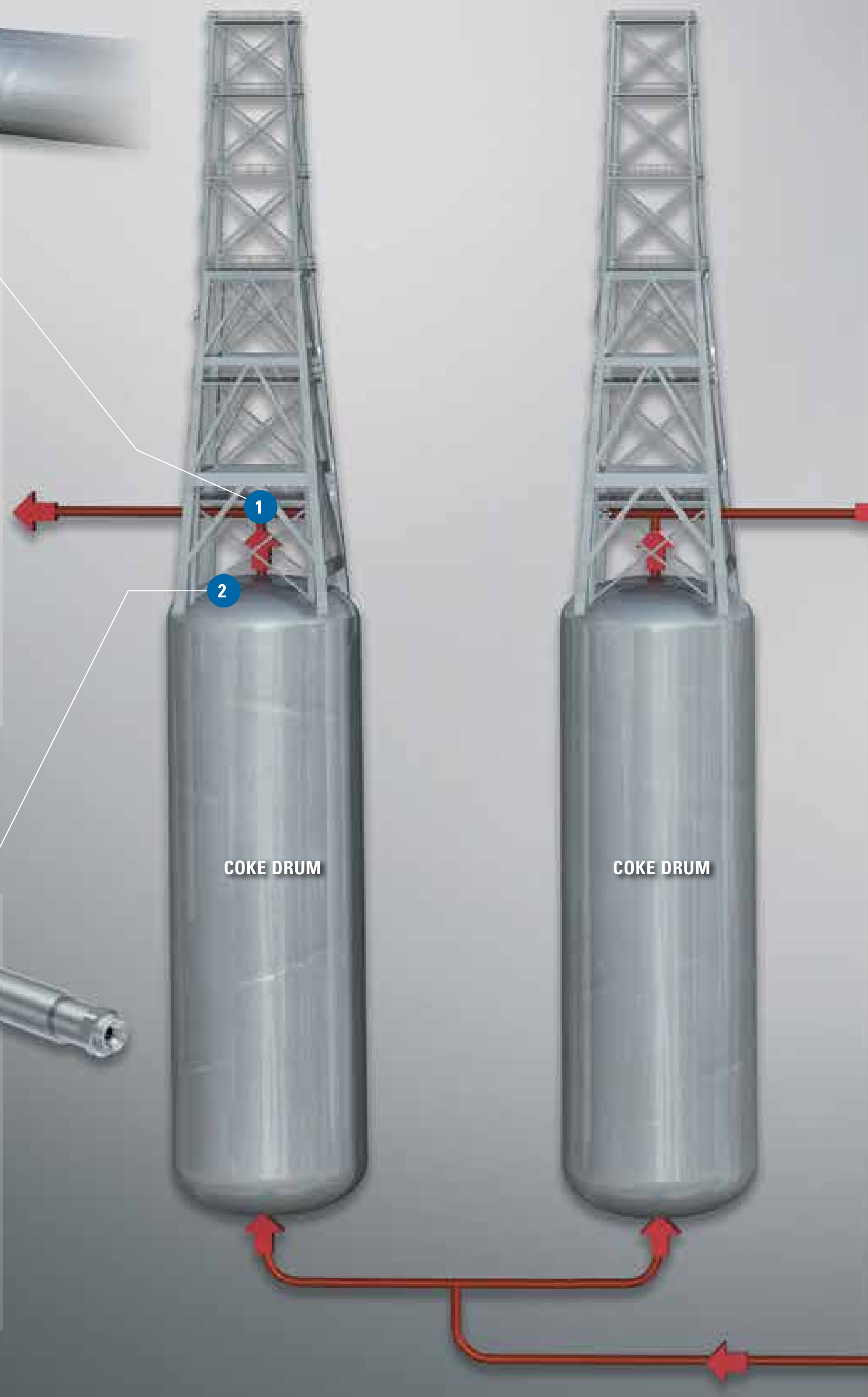
Full cone and hollow cone spray nozzles form discrete droplets. However, the droplets are too large to navigate the tee and bends in piping systems installed prior to the introduction of REACs. In addition, large droplets tend to form a water film in the piping system and are susceptible to maldistribution and reduced salt dissolution.

FLOMAX H

Two-fluid FloMax H spray nozzles have been engineered to optimize chloride scrubbing in water wash systems in hydroprocessing units. A slipstream of makeup hydrogen is used for atomization. The nozzle produces smaller droplets that saturate more of the vapor while maintaining 20 to 25% free water. The result is more uniform distribution of the droplets for chloride scrubbing in the piping, REAC inlets and exchanger tubes.


MAKEUP
HYDROGEN
RECYCLE GAS
COMPRESSOR
1
CHPS
HHPS
STRIPPER
CONDENSER
STRIPPER OH ACCUMULATOR
CLPS
STRIPPER

COKER



1. QUENCH SPRAYS

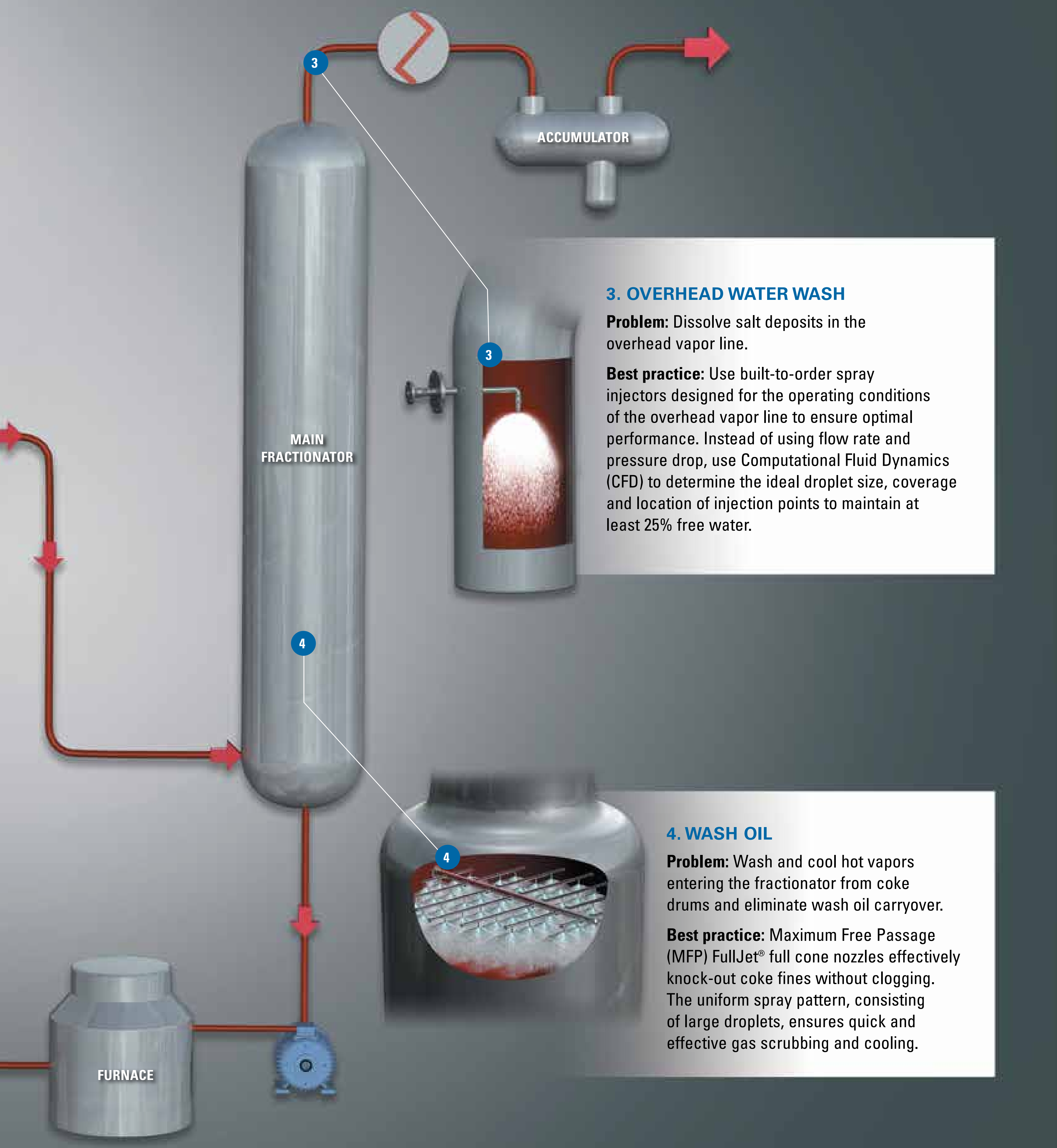
Problem: Slow the cracking reaction while preventing coke formation in the overhead line.

Best practice: Use Maximum Free Passage (MFP) FullJet® full cone spray nozzles to inject coker gas oil into the drum outlet tee to quench and slow the cracking reaction. The nozzles are available with a wide range of spray angles to ensure a thin liquid film is maintained on the walls. Open flow passages resist plugging and provide longer service life before maintenance is required.

2. DEFOAMING

Problem: Foam elimination.

Best practice: MFP FullJet full cone spray nozzles feature a patented vane design that provides the largest free passage of maximum free passage nozzles to minimize clogging with uniform spray distribution. MFP FullJet nozzles provide excellent coverage at lower operating pressures.



3. OVERHEAD WATER WASH

Problem: Dissolve salt deposits in the overhead vapor line.

Best practice: Use built-to-order spray injectors designed for the operating conditions of the overhead vapor line to ensure optimal performance. Instead of using flow rate and pressure drop, use Computational Fluid Dynamics (CFD) to determine the ideal droplet size, coverage and location of injection points to maintain at least 25% free water.

4. WASH OIL

Problem: Wash and cool hot vapors entering the fractionator from coke drums and eliminate wash oil carryover.

Best practice: Maximum Free Passage (MFP) FullJet® full cone nozzles effectively knock-out coke fines without clogging. The uniform spray pattern, consisting of large droplets, ensures quick and effective gas scrubbing and cooling.

ADDITIONAL WAYS TO OPTIMIZE OPERATIONS

APPLICATION	LOCATION	SPRAY EQUIPMENT	DESCRIPTION
H_2S Scavenger	Flare Gas Line	FM01S Steam Atomizing Injector	To obtain the small droplets required for better surface area coverage, two-fluid steam atomizing injectors are ideal. Operating at low flow rates, injectors using available plant steam for atomization provide unmatched efficiency and economy.
Solvent Injection	Compressor Inlet	Low Flow Rate Injectors with Hydraulic Fine Spray Nozzles or Two-Fluid Nozzles	Keep exchangers and compressors running smoothly by preventing hydrate formation. Solvent injectors with nozzles that produce small droplets at relatively low flow rates are widely used. Nozzle selection dependent on chemistry and process conditions.
Spent Acid	Spent Acid Regenerator (SAR)	FloMax® Alky Injector	Maximize operating flexibility by using injectors with a high turndown ratio. Air pressure remains constant while the liquid varies based on process requirements. In addition to turndown ratios up to 10:1, FloMax Alky Injectors produce smaller droplets while operating at higher flow rates and are available in special materials such as Hastelloy® and Alloy 20 to withstand the severe conditions of the Spent Acid Furnace.
Emergency Water Deluge	HF Alkylation Unit	SpiralJet® Spray Nozzles	SpiralJet nozzles ensure maximum liquid throughput and feature open passages to minimize the risk of clogging. Available with spray angles up to 180°, flow rates up to 3320 gpm (12,568 lpm) and operating pressure up to 400 psi (25 bar), SpiralJet nozzles are an industry standard for emergency quenching and fire protection.

ADDITIONAL SOLUTIONS:

- Replacement Nozzles for Isobutane and Olefin Injection
- High Flow Rate Injectors for Temperature Loop Control

APPLICATION	LOCATION	SPRAY EQUIPMENT	DESCRIPTION
Ammonia Injection	Various	FloMax® Injectors	Smaller drops maximize surface area coverage and help ensure an optimal reaction between the aqueous ammonia and process stream. FloMax injectors use a patented multi-stage atomization process to produce very small drops using minimal air.
Heat Exchanger Reliability	Various	Modeling and Simulation	Non-uniform, turbulent flow patterns make it difficult to determine how best to inject solvents or other chemicals prior to a heat exchanger tube sheet to prevent pluggage and erosion. The use of Computational Fluid Dynamics (CFD) using actual process conditions can determine the ideal drop size and injector placement.
Desuperheating	Various	Hydraulic or Two-Fluid Injector	To bring superheated steam near its saturated state, hydraulic fine mist injectors and FloMax injectors are widely used. Both of these injectors produce small drops and maximize surface area coverage.
Propane Condenser and Fin Fan Coolers	Various	HP FogJet® Nozzles	HP FogJet nozzles create very small droplets without compressed air. The nozzles provide rapid cooling of the condenser intake air and improves propane cooling efficiency.
Tank Mixing	De-Coking and Tank Farms	Eductors or Jet Mixers	Eductors and jet mixers are gaining widespread use and replacing propellers, agitators and open-end pipe to prevent settling on tank floors and build-up on tank walls. Tank eductors typically provide better mixing using less energy and more reliable operation than other equipment. The use of modeling is recommended to determine the ideal placement of the eductors, mixing time and solution uniformity.

SERVICES TO VALIDATE PERFORMANCE PRIOR TO DESIGN & FABRICATION

COMPUTATIONAL FLUID DYNAMICS (CFD)

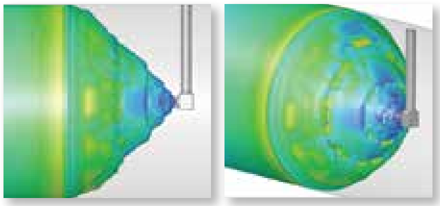
Spray equipment used in refineries is built-to-order to meet specific process conditions. Prior to equipment fabrication, CFD is often recommended to validate performance and avoid costly and dangerous problems. Modeling the fluid flow, heat and mass transfer, chemical reactions and more using actual operating conditions will reveal potential costly problems such as wall wetting, refractory cracking, duct corrosion, premature equipment failures and unscheduled outages.

Our models are highly accurate. Instead of using theoretical calculations for the models, we use our proprietary data library compiled from actual testing completed in our spray laboratories.

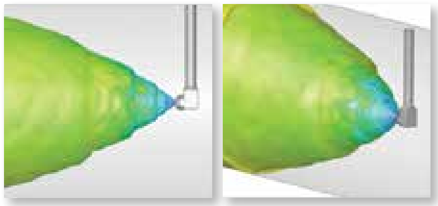
CFD EVALUATES CRITICAL CHARACTERISTICS:

SPRAY VISUALIZATION OF PATTERN

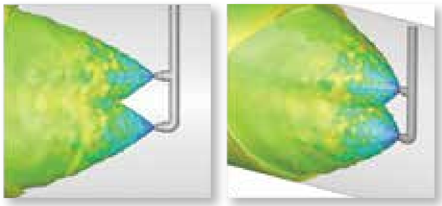
Hollow Cone



Full Cone

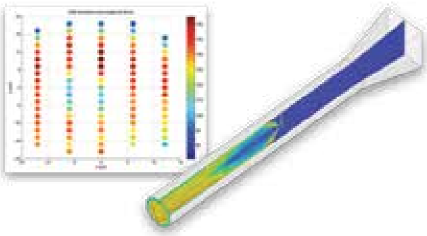


Dual Full Cone

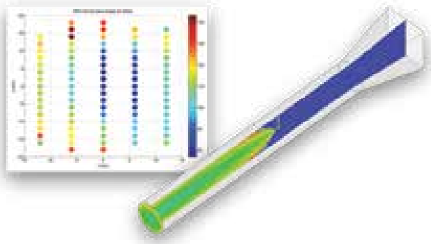


DROP SIZE DISTRIBUTION

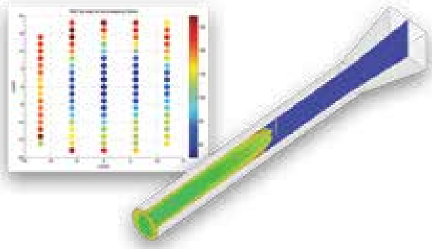
Hollow Cone



Full Cone

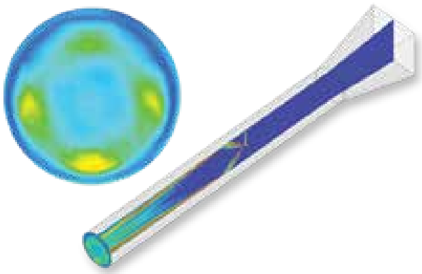


Dual Full Cone

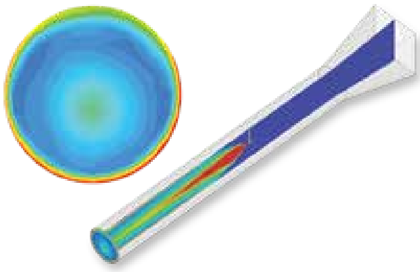


SPRAY DISTRIBUTION

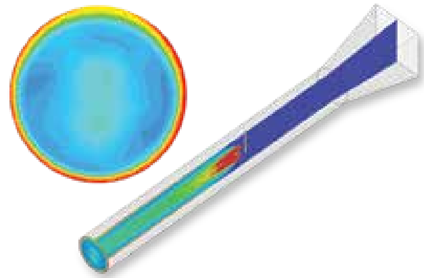
Hollow Cone



Full Cone

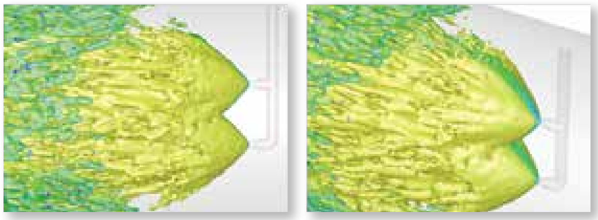


Dual Full Cone

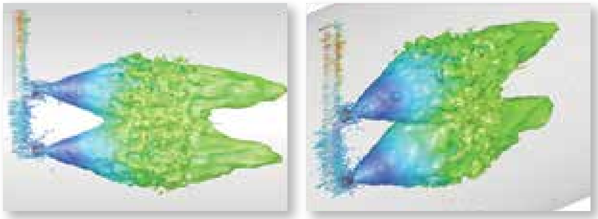


CO- AND COUNTER-CURRENT SPRAYING

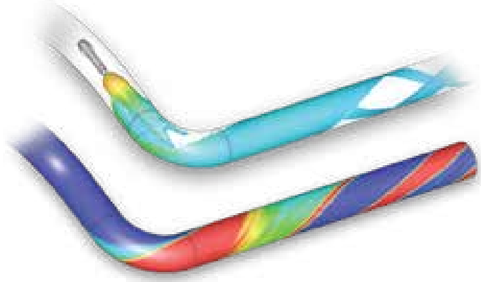
Co-current



Counter-current



WALL WETTING BASED ON INJECTOR PLACEMENT



FLUID STRUCTURE INTERACTION (FSI)

FSI modeling examines the interaction between fluid flow at various conditions and the affected solid structures to evaluate vibration, thermal failure and fatigue.

BUILT TO EXACTING SPECIFICATIONS & STANDARDS

The process conditions will determine many of the final specifications of the spray equipment and compliance requirements. Some specifications may be less obvious. In some operations, there are multiple ways to accomplish similar outcomes. That's when experience really matters. Working with engineering specialists with a proven track record in both refinery operations and spray technology can be the difference between acceptable performance and optimal performance/service life. With decades of experience designing and manufacturing spray equipment for refineries, we can guide your decision-making based on real world experience.

MANUFACTURING CODE COMPLIANCE

- ASME® Boiler & Pressure Vessel Code (BPVC)
- ASME U-Stamp Vessel Manufacturing
- ASME B31.1
- ASME B31.3
- ASME BPVC Section IX

CERTIFICATIONS

- ISO 9001-2018 and ISO 14001-2018
- ASME BPVC Section VIII
- Canadian Registration Number (CRN)
- Pressure Equipment Directive (PED)

OPTIONAL TESTING & VALIDATION

- Hydrostatic testing (LT)
- Material traceability (MTR)
- Liquid penetrant examination (PT)
- Radiographic examination (RT)
- Visual testing (VT)
- Weld maps
- Ferrite weld testing
- Ultrasonic examination (UT)
- Spray and flow testing
- Letter of compliance

SPRAY EQUIPMENT FOR REFINERIES

- Hydraulic injectors
  - FullJet® full cone, Maximum Free Passage (MFP) FullJet full cone, WhirlJet® hollow cone, SpiralJet® and FogJet® spray nozzles
- Air/steam/gas atomizing injectors
  - FloMax® air, steam and hydrogen atomizing nozzles
- Single and multi-nozzle injectors
- Water-jacketed and insulated injectors
- Recirculating injectors
- Desuperheating injectors
- Retractable injectors
- Tank mixing eductors

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

ISO 9001:2015 14001:2015 CERTIFIED