eBook

HOW OPTIMIZED FILTRATION SOLUTIONS SOLVE COMMON PROBLEMS IN COMPLEX REFINERY APPLICATIONS

Filtration Group®
Process Technologies

INTRODUCTION

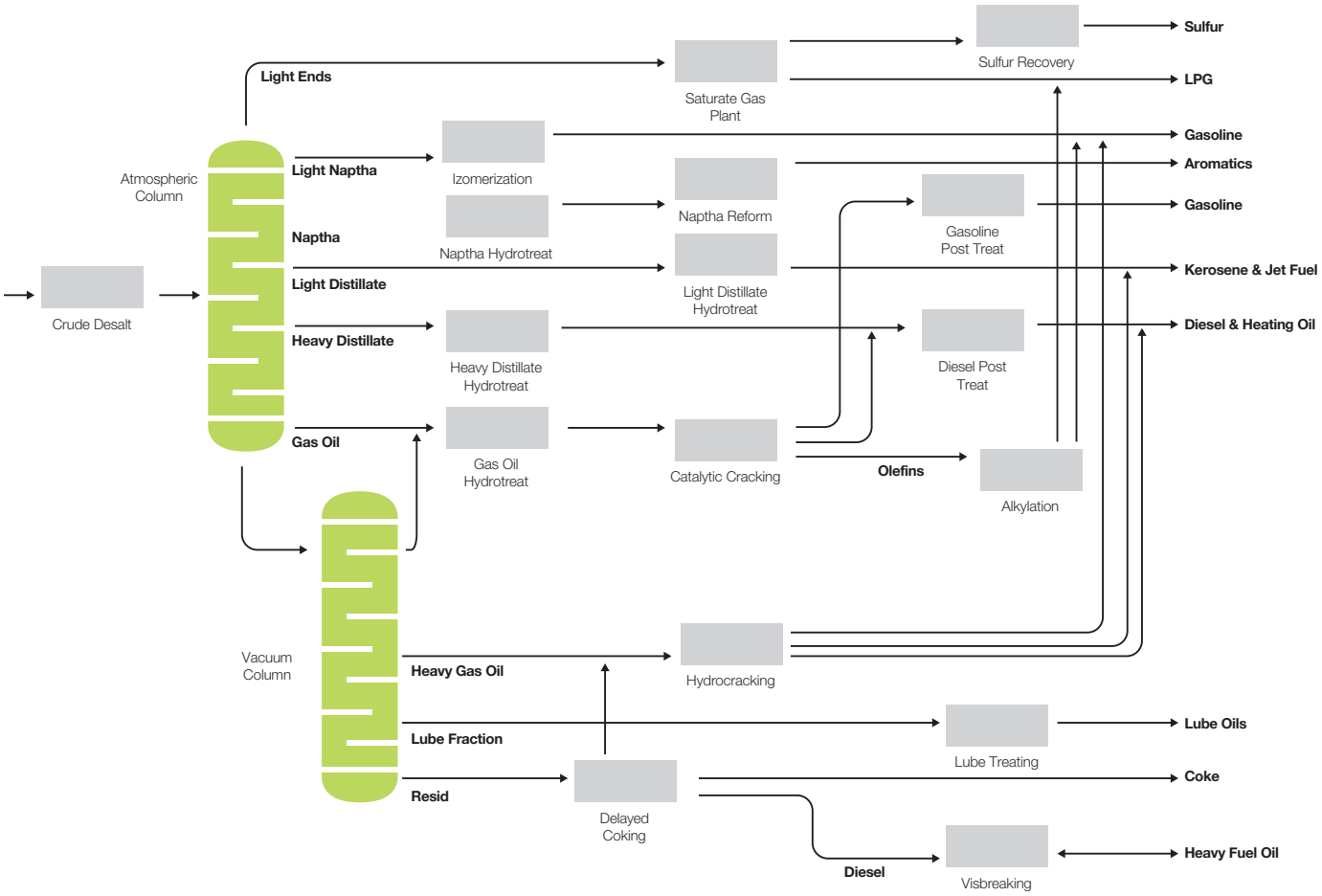
Oil and gas refining rely on the purity of feed streams for efficient process reactions and a high-quality product.

However, there are common challenges in complex refinery applications which prevent them from achieving optimal productivity, efficiency and cost-effectiveness. These challenges are typically a result of contamination management. Contamination can result in equipment not performing as it should be, or causing long-term damage to equipment and unplanned downtime. This can quickly lead to costly maintenance, efficiency and quality issues.

Now for the good news: Optimised filtration solutions can be used to mitigate these challenges by maximising contaminant removal at every stage, minimising maintenance downtime, protecting equipment, and improving productivity.

This ebook will look at eight key processes, common problems, and show how proven filtration solutions can offer business benefits.

Major Processes in Modern Refineries



Process 1: Aromatic Fractionation

Aromatic Fractionation, or BTX Extraction, is when a refinery utilizes reformate from the catalytic reformer and extracts the aromatics, rather than blending them into gasoline.

The aromatics are separated in pure benzene, toluene, and mixed xylenes products at the BTX (benzene-toluene-xylene) Unit. The BTX is then either processed by a chemical unit within the refinery or sold to a chemical facility for production into a wide range of chemicals from solvents, to fibers, films, and plastics.

How BTX Extraction works

For most BTX extraction units, the recovery of aromatics occurs in a liquid-liquid extractor column, while the purification takes place in an extractive distillation column. Steam stripping is used to remove the aromatics from the solvent.

Common Problems

The most common problems in aromatic fractionation are:

Foaming: Solid particulates cause foaming, resulting in reduced process flow and the injection of costly foaming inhibitors to regain control.

Fouling: Occurs from excessive particulate concentrations and reduces operating efficiencies in distillation and recovery towers, heat exchangers, and other downstream equipment.

To meet sales quality specifications of BTX products, an optimal filtration system is required to remove both solid and liquid contaminants.

Benefits of an Optimized Filtration System

There are three recommended filter solutions, each offering unique benefits:

1. LiquiPleat Series Pleated Style Liquid Elements

This removes scale and solid contaminants, including iron sulfites. As a result, it protects downstream equipment, prevents heat exchanger and tower fouling and reduces foaming problems. This reduces or eliminates the need for costly anti-foaming inhibitors.

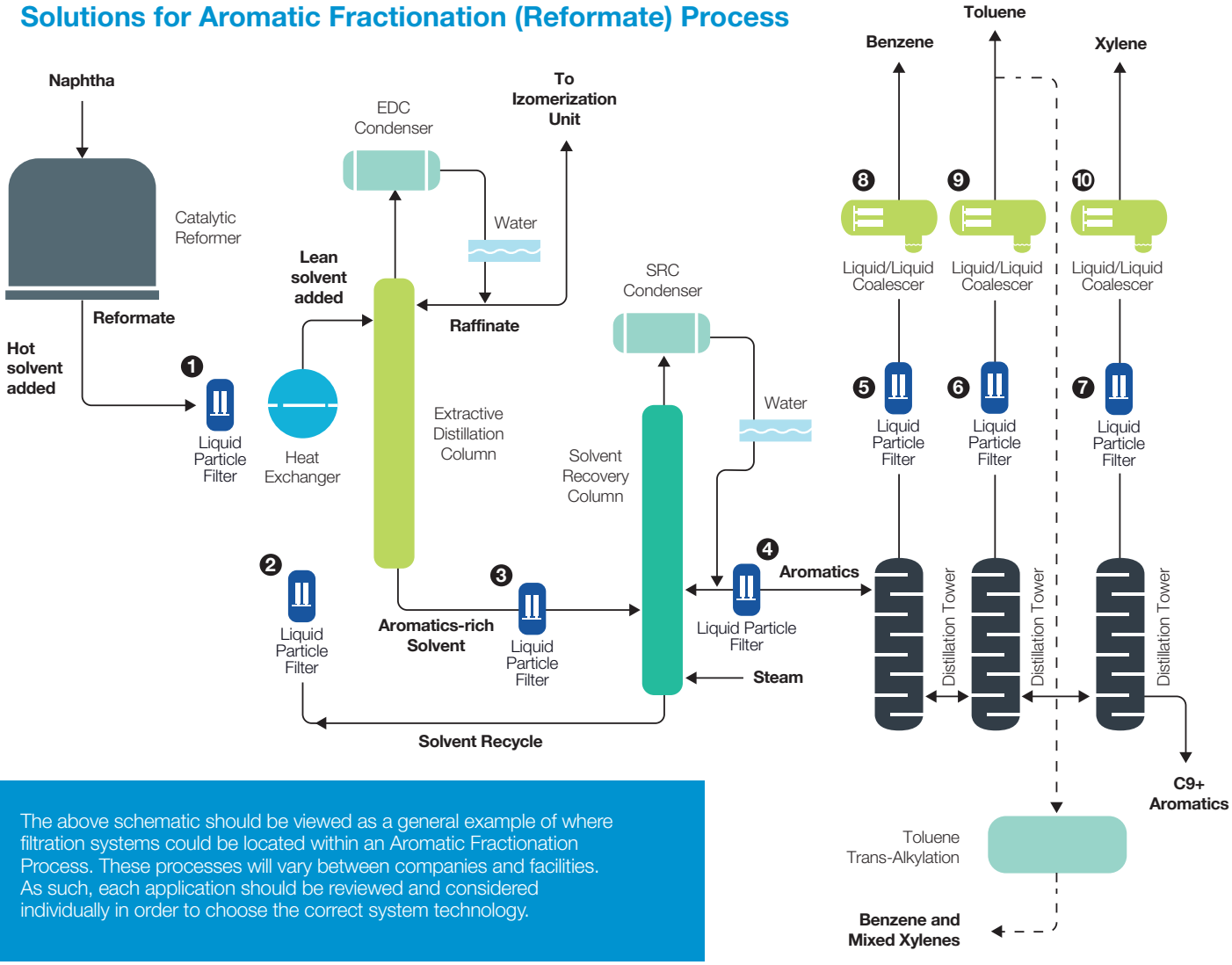
2. LiquiPleat HF Series “High Flow” Pleated Style Liquid Elements

This solution removes solid particulates from the final product, which protects coalescers and other downstream equipment. It also allows the coalescers to more efficiently remove water from the final product.

3. PhasePUR or Phase-LOK Series Liquid/Liquid Coalescing Elements

The third solution removes suspended water from the final product, which is key to maintaining the sales specification. Crucially, it also reduces disposal, maintenance and reprocessing costs.

Solutions for Aromatic Fractionation (Reformate) Process



The above schematic should be viewed as a general example of where filtration systems could be located within an Aromatic Fractionation Process. These processes will vary between companies and facilities. As such, each application should be reviewed and considered individually in order to choose the correct system technology.

	Filter Solution	Filter Purpose	Filter Benefit
1-4	LiquiPleat™ Series Pleated Style Liquid Elements and Vessels	Removes scale and solid contaminants including iron sulfites.	Protects downstream equipment. Prevents heat exchanger and tower fouling. Reduces foaming problems.
5-7	LiquiPleat™ HF Series “High Flow” Pleated Style Liquid Elements and Vessels	Removes solid particulates from the final product.	Protects coalescers and other downstream equipment. Allows efficient operation of coalescers to remove water from the final product.
8-10	PhasePUR™ or Phase-LOK™ Series Liquid/Liquid Coalescing Elements and Vessels	Removes suspended water from the final product.	Maintains sales specification of final product. Reduces disposal, maintenance, and reprocessing costs.

Process 2: Delayed Coking

The key benefit of delayed coking is full conversion of heavy residual oils, such as vacuum resid, to lighter products. Refiners can use this to increase profit margins by processing lower-cost, heavier crude slates.

Light products from the delayed coker go on to be treated in other process units to produce transportation fuels, such as gasoline and diesel.

Petroleum coke is produced as a by-product and has applications in the electric power and industrial sectors as fuel inputs, or as manufacturing raw material to produce electrodes for the steel and aluminum industries.

How delayed coking works

The delayed coking process uses furnaces, coke drums and a main fractionator. Cracking and coking reactions are initiated in the furnaces under controlled time and temperature-pressure conditions. High velocities are maintained in the furnaces in order to prevent significant coke formation.

Reactions continue as the process stream moves to the coke drums. Here, the coking reaction rate drops dramatically as coke-drum temperature decreases and coke is deposited in the drums to be collected and sold.

The vapor is routed to the fractionator, where it is condensed and fractionated into product streams, typically fuel gas, LPG, naphtha, distillate, and gas oil.

Solid and liquid contaminants enter the fractionated products as coke fines and injected steam. Both particulates and water need to be removed to meet final product specifications and feedstock requirements.

Benefits of an Optimized Filtration System

There are three recommended filtration systems which together will improve operation and process efficiency, and produce a higher quality product:

1. Backwashable ProGuard Series filter systems OR Replaceable LiquiPleat HF Series Elements and Vessels

The filter system removes solid contaminants, such as scale, rust and coke particulates, from the coker gas oil feedstock. This protects the downstream hydrotreating / hydrocracking catalyst, prevents unscheduled reactor downtime, and reduces fouling in heat exchangers. As a result, the time is extended between maintenance and shutdowns with fewer catalyst changeouts required

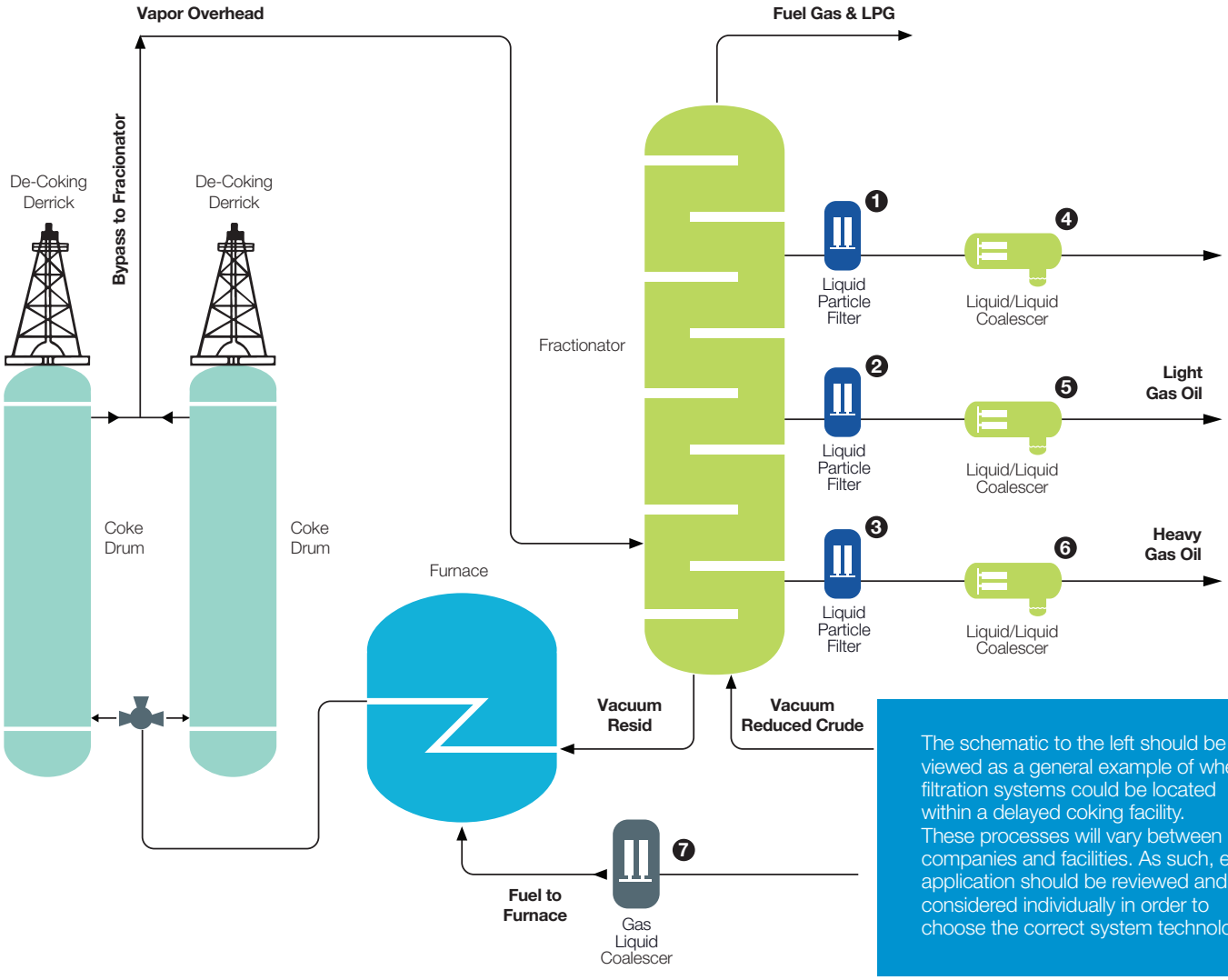
2. Phase-LOK or Phase-PUR Series Liquid/Liquid Coalescers

Removing liquid contaminates from the final product also protects downstream equipment and maintains final product and feedstock specifications.

3. Micro-LOK or Micro-DEP Series Gas/Liquid Coalescers

Removing liquid and solid contaminants from fuel gas is essential to improve burner efficiency, provide a longer service life, and reduce maintenance costs.

Solutions for Aromatic Fractionation (Reformate) Process



The schematic to the left should be viewed as a general example of where filtration systems could be located within a delayed coking facility. These processes will vary between companies and facilities. As such, each application should be reviewed and considered individually in order to choose the correct system technology.

	Filter Solution	Filter Purpose	Filter Benefit
1*, 2*, 3*	Backwashable ProGuard Series filter systems or Replaceable LiquiPleat HF Series.	Removal of coke fines and solid contaminants.	Protect liquid coalescers and downstream equipment. Maintain final product and feedstock specifications.
4, 5, 6	Phase-LOK™ or Phase-PUR™ Series Liquid/Liquid Coalescers.	Removal of liquid contaminates from the final product.	Protection of downstream equipment. Maintain final product and feedstock specifications.
7	Micro-LOK™ or Micro-DEP™ Series Gas/Liquid Coalescers.	Removal of liquid and solid contaminants from fuel gas.	Improved burner efficiency, longer service life, and reduced maintenance costs.

*A wide range of absolute and nominal pre-filters and filters are available to meet specific process applications. To answer more questions about filtration applications, replacement needs, or help troubleshooting process issues, contact an approved Filtration Group® representative or Filtration Group® direct.

Process 3: Hydrocracking

Hydrocracking is a refining process that converts heavy oils into lighter distillates, such as naphtha, kerosene, diesel, etc. This process can significantly improve refining margins by upgrading lower-value products into higher-value, high demand products. Not every refinery has a hydrocracker, though as demand for middle distillates, such as jet fuel, kerosene and diesel increase, refiners are finding an incentive to build them to increase distillate yield. In the low-sulfur world, the hydrocracker is part of the process of converting high-sulfur materials into low-sulfur fuels for vehicles, ships, and airplanes

How Hydrocracking works

The two main chemical reactions in a hydrocracker are:

1. Catalytic cracking of heavy hydrocarbons into lighter unsaturated hydrocarbons.

2. Saturation of these newly formed hydrocarbons with hydrogen.

As the hydrocracking takes place, sulfur, nitrogen, and oxygen are almost completely removed, and olefins are saturated. Products are therefore a mixture of essentially pure paraffins, naphthenes, and aromatics.

Common Problems

Key contamination problems with hydrocracking include:

- Particulate fouling around the process unit feed pumps and heat exchangers
- Carry-over hydrocarbons contaminating the recycled hydrogen compressor
- Carry-over lube oils from the recycled hydrogen compressor
- Trace hydrocarbon liquids contaminating the amine in the hydrogen recovery unit
- Trace water contamination in final products

Benefits of an Optimized Filtration System

Filter solutions include:

1. Backwashable ProGuard Series filter systems OR Replaceable LiquiPleat HF Series Elements and Vessels

The filter system removes solid contaminants, such as scale, rust and particulates, from the hydrocracker feedstock. This protects the coalescer, prevents unscheduled reactor downtime, and reduces fouling in heat exchangers. As a result, the time is extended between maintenance and shutdowns with fewer catalyst changeouts required.

2. Phase-LOK or Phase-PUR Series Liquid/Liquid Coalescers

Removing water from the hydrocracker feedstock has many benefits, including preventing unscheduled reactor downtime, reducing heat exchanger fouling, protecting downstream equipment, and extending the catalyst bed life.

Also, use this system to remove liquid contaminants from fractionator feedstock. This maintains fractionator efficiency by preventing contamination build up on separator plates.

Removing trace water contamination from the final product helps protect downstream equipment and maintain final product specifications.

3. Micro-LOK or Micro-DEP Series Gas/Liquid Coalescers

By removing liquids and solids from recycled hydrogen, you gain more efficient hydrogen compressor operation and significantly reduced maintenance costs.

Using this filter system to remove lube oil from compressor discharge gas also lowers maintenance costs as well as improving reactor efficiency.

This is also used to remove trace hydrocarbon liquids from the sour process gas, which prevents amine contamination in the hydrogen recovery unit.

4. LiquiPleat Series Pleated Liquid Elements and Vessels

By removing solid particulates from the fractionator feedstock, you can improve coalescer efficiency and protect downstream equipment.

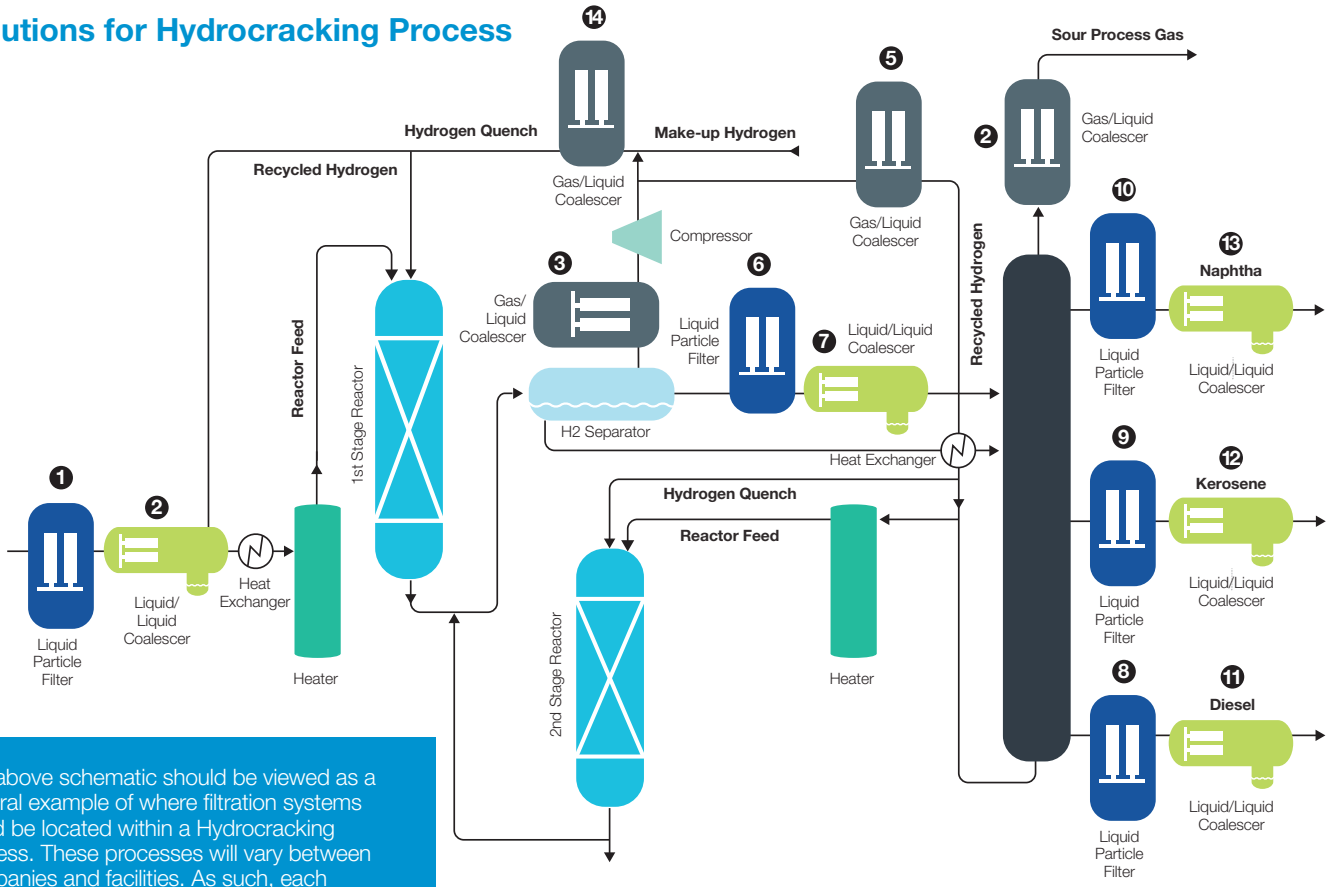
5. LiquiPleat HF Series High Flow Liquid Elements and Vessels

Remove solid contaminants from the fractionator and you can effectively protect liquid coalescers and downstream equipment, while maintaining final product specifications.

Together, the filtration systems offer the following benefits:

- Reduced hydrogen contamination
- Protection of downstream equipment
- Reduced reactor bed plugging or fouling
- Ability to meet final product sales specification
- Reduced heat exchanger fouling and improved heat transfer performance
- Improved operation and process efficiency

Solutions for Hydrocracking Process



The above schematic should be viewed as a general example of where filtration systems could be located within a Hydrocracking process. These processes will vary between companies and facilities. As such, each application should be reviewed and considered individually in order to choose the correct system technology.

	Filter Solution	Filter Purpose	Filter Benefit
01	Backwashable ProGuard Series filter systems or Replaceable LiquiPleat HF Series.	Removal of solid contaminants, such as scale, rust, and particulates from the hydrocracker feedstock.	Protects coalescer, prevents unscheduled reactor downtime, reduced fouling in heat exchangers extending time between maintenance and shutdowns, fewer catalyst change outs.
02	Phase-LOK™ or Phase-PUR™ Series Liquid/Liquid Coalescers.	Removal of water from hydrocracker feedstock.	Prevents unscheduled reactor downtime, heat exchanger fouling, protection of downstream equipment, and extends catalyst bed life.
03	Micro-LOK™ or Micro-DEP™ Series Gas/Liquid Coalescers.	Removal of liquids and solids from recycled hydrogen.	Efficient hydrogen compressor operation and significantly reduced maintenance costs.
4-5	Micro-LOK™ or Micro-DEP™ Series Gas/Liquid Coalescers.	Removal of lube oil from compressor discharge gas.	Lower maintenance costs and improved reactor efficiency.
06	LiquiPleat™ Series Pleated Liquid Elements and Vessels.	Removal of solid particulates from fractionator feedstock.	Improves coalescer efficiency and protects downstream equipment.
07	Phase-LOK™ or Phase-PUR™ Series Liquid/Liquid Coalescers.	Removal of liquid contaminants from fractionator feedstock.	Maintains fractionator efficiency by preventing contamination build up on separator plates.
8-10	LiquiPleatTM HF Series High Flow Liquid Elements and Vessels.	Removal of solid contaminants from the fractionator.	Protect liquid coalescers and downstream equipment. Maintain final product specifications.
11-13	Phase-LOKTM or Phase PURTM Series Liquid/Liquid Coalescers.	Removal of trace water contamination from the final product.	Protection of downstream equipment. Maintain final product specifications.
14	Micro-LOKTM or Micro-DEPTM Series Gas/Liquid Coalescers.	Removal of trace hydrocarbon liquids from the sour process gas.	Prevention of amine contamination in the hydrogen recovery unit.

Process 4: Hydrotreating

Hydrotreating is an essential refinery process for cleaning petroleum fractions from impurities such as sulfur, nitrogen, oxy-compounds, chloro-compounds, aromatics, waxes and metals using hydrogen. Removing the contaminants through hydrogen and solid catalyst treatment produces higher quality fuel oil and catalytic cracker feedstocks.

The objectives of Hydrotreating are to:

- Remove contaminants with minimal effect on the boiling range of fuel
- Help the saturation of olefins and some aromatics
- Meet product quality, performance and environmental product regulations
- Improve downstream processes and catalyst performance
- Increase the Cetane rating of diesel

Types of Hydrotreating

- **Gasoline Hydrotreating:** Removes sulfur from gasoline blending components and reduces the olefins and aromatics content by saturating the double bonds with hydrogen.
- **Jet Fuel Hydrotreating:** Improves burning characteristics of jet fuel by increasing the smoke point at which unburned hydrocarbons are released as smoke.
- **Distillates Hydrotreating:** Distillates used for diesel fuel are hydrotreated to reduce sulfur content to meet ultra-low-level sulfur mandates. In addition, hydrotreating cracked light oils reduces the amount of aromatics compounds and raises the octane levels.
- **Cat Feed and Reformer Feed Hydrotreating:** Cat reformer feeds are almost always hydrotreated prior to entering the catalyst to protect the equipment and maintain optimal operating conditions.

Additional hydrotreating processes including Pyrolysis Gas, Kerosene, Residual Fuels, etc.

How Hydrotreating works

- Hydrotreater feed is filtered to remove solid and liquid contaminants, and is then preheated by the reactor effluent.
- Hydrogen is combined with the feed and heated using a fired heater to the desired hydrotreating temperature.
- The feed and hydrogen pass through a hydrogenation reactor packed with various catalysts depending on the specific reaction required.
- Reactor effluent is cooled and enters the separator to separate the hydrogen from the liquid hydrocarbons and acid gas.
- Purged hydrogen is filtered and recycled with make-up hydrogen.
- Acid gases are separated from hydrocarbon liquids in the steam stripper.
- Hydrocarbon liquids are filtered to remove solid and liquid contaminants before transfer to fractionation

Common Problems

One of the most common problems is solid and liquid contaminants being in the fluid and gas streams from upstream equipment, storage tanks and piping.

These contaminants foul the reactor beds, which results in a higher differential pressure. This leads to a reduction in recycle hydrogen compressor performance, which causes refiners to reduce gas oil throughput in order to maintain the proper hydrogen to gas oil ratio. The result? Direct revenue losses.

Another problem is that contamination fouling causes catalyst deactivation (coking), meaning refiners need to raise temperatures in the reactor to compensate. If elevated long enough, deactivation occurs, making it difficult to maintain on-spec product and leading to unplanned shutdowns to replace the fouled catalyst.

In addition, contamination in hydrotreater feed streams cause problems in heat exchangers and hydrogen compressors leading to costly repairs and downtime.

Wash water is used to remove salts to prevent the formation of NH4Cl and NH4HS. This wash water is then designated as Sour water. Water is also produced in the reactor as a result of the conversion of organic oxygen compounds. The Sour water is removed in a separator. Any Hydrocarbon carryover along with the Sour water leads to fouling of the sour water stripper column, which is not desirable. The Hydrotreated product needs to be free of water before it is fed to downstream catalytic process like a reformer, because presence of water acts as a catalyst poison.

Benefits of an Optimized Filtration System

Each stage of the process has a filtration solution for maximum benefits:

1. Backwashable ProGuard Series filter systems OR LiquiPleat HF Series (High Flow) filter elements and vessels

Hydrotreater feed filtration removes solid contaminants such as scale, rust, and solid particles. This prevents unscheduled reactor downtime and reduced fouling in heat exchangers, which extends time between maintenance and shutdowns. It also means fewer catalyst change-outs.

2. PhasePUR or Phase-LOK Series coalescing elements and vessels

Removing water from hydrotreater feedstock prevents unscheduled reactor downtime, heat exchanger fouling, and extends the catalyst bed life.

Later in the process, water removal from stabilized fuel ensures refineries can maintain liquid fuel specifications, protect downstream equipment, and reduce maintenance costs.

3. LiquiPleat HF Series (High Flow) filter elements and vessels

By removing solid contaminants, such as scale and rust, from desulfurized product, you can protect downstream equipment and reduce associated maintenance and labour costs.

4. Micro-LOK or Micro-DEP Series coalescing elements and vessels

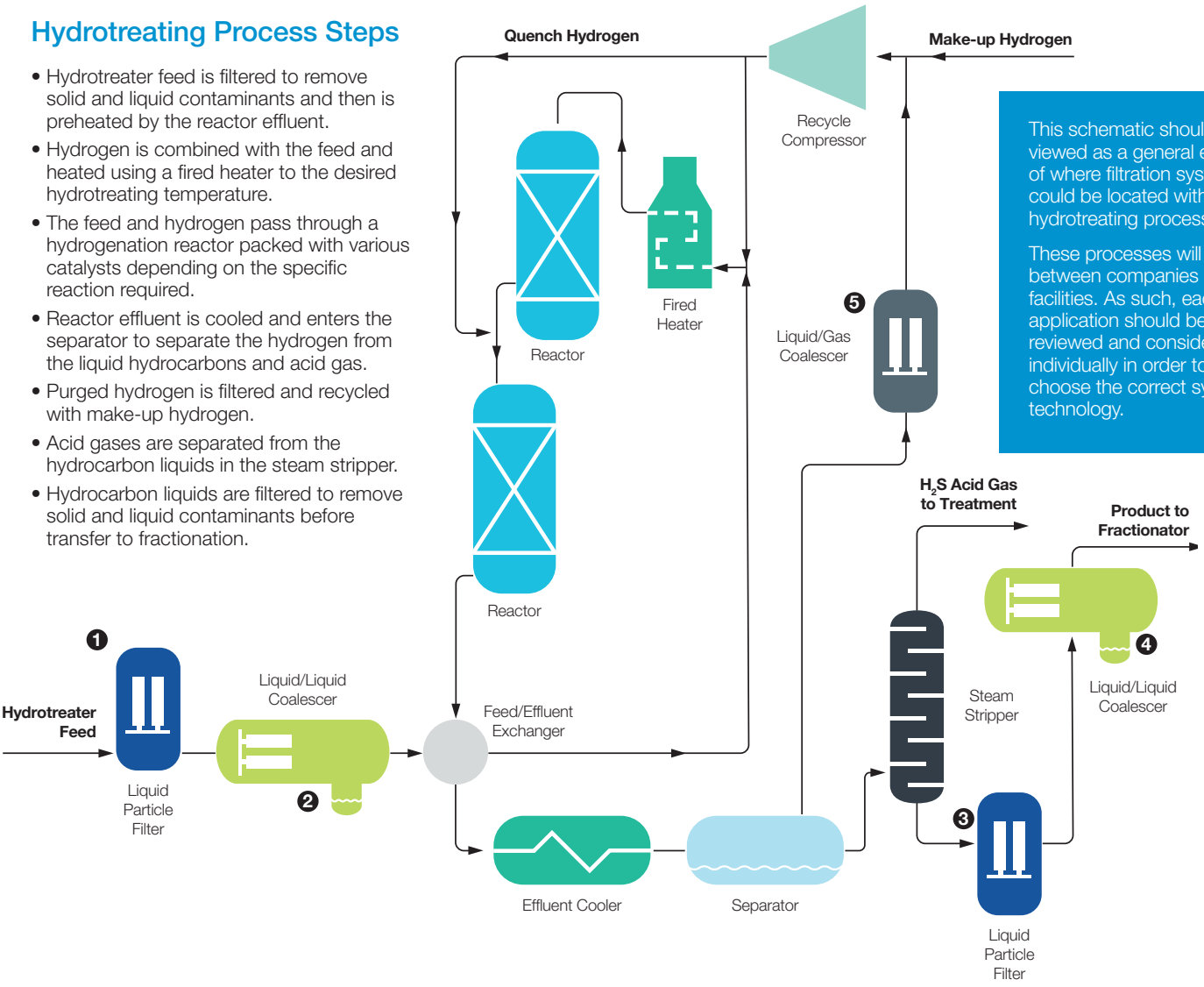
Removal of liquids and solids from recycle hydrogen causes efficient hydrogen compressor operation and significantly reduced maintenance costs.

Together, this filtration solution offers the following benefits:

- Maintains stringent clean fuel requirements
- Improves production and operation efficiency
- Extends catalyst bed life
- Protects downstream equipment
- Reduces process upsets and downtime

Hydrotreating Process Steps

- Hydrotreater feed is filtered to remove solid and liquid contaminants and then is preheated by the reactor effluent.
- Hydrogen is combined with the feed and heated using a fired heater to the desired hydrotreating temperature.
- The feed and hydrogen pass through a hydrogenation reactor packed with various catalysts depending on the specific reaction required.
- Reactor effluent is cooled and enters the separator to separate the hydrogen from the liquid hydrocarbons and acid gas.
- Purged hydrogen is filtered and recycled with make-up hydrogen.
- Acid gases are separated from the hydrocarbon liquids in the steam stripper.
- Hydrocarbon liquids are filtered to remove solid and liquid contaminants before transfer to fractionation.



This schematic should be viewed as a general example of where filtration systems could be located within a hydrotreating process.

These processes will vary between companies and facilities. As such, each application should be reviewed and considered individually in order to choose the correct system technology.

	Filter Solution	Filter Purpose	Filter Benefit
01	LiquiPleat™ HF Series (High Flow) filter elements	Hydrotreater feed filtration removes solid contaminants such as scale, rust, and solid particles	Prevents unscheduled reactor downtime; reduced fouling in heat exchangers extending time between maintenance and shutdowns; fewer catalyst change-outs
02	PhasePUR™ or Phase-LOK™ Series coalescing elements	Removal of water from hydrotreater feedstock	Prevents unscheduled reactor downtime, heat exchanger fouling, and extends catalyst bed life
03	LiquiPleat™ HF Series (High Flow) filter elements	Removes solid contaminants such as scale and rust from desulfurized product	Protects downstream equipment, reduces maintenance and labor costs
04	PhasePUR™ or Phase-LOK™ Series coalescing elements	Water removal from stabilized fuel	Maintains liquid fuel specifications, protects downstream equipment, and reduces maintenance costs
05	Micro-LOK™ or Micro-DEP™ Series coalescing elements	Removal of liquids and solids from recycle hydrogen	Efficient hydrogen compressor operation and significantly reduced maintenance costs

Process 5: Gas Sweetening

Gas Sweetening is a critical procedure in gas processing facilities. To meet sales specifications and maintain efficient operations, natural gas goes through a sweetening process to remove contaminants; primarily H2S because of its corrosiveness and C02 for its lack of heating value. Amine solvents are widely used to remove these contaminants from natural gas or lighter hydrocarbon products.

Typical industries that perform gas sweetening include: gas production sites, gas processing plants, refineries, LNG facilities, petrochemicals, etc.

Common Problems

The most common filtration problems in an amine unit are:

- **Foaming:** Reduces effective absorption in the contactor tower resulting in high amine carryover rates and replacement costs. Treatment of gas extraction will dramatically decrease resulting in reduced flow and the injection of costly foaming inhibitors to regain control of the amine system.
- **Fouling:** Occurs from excessive particulate concentrations and can lead to poor amine/feed gas contacting and off-spec gas. Resulting problems include: tray plugging in the absorber and regenerator towers, heat exchanger/reboiler failure, carbon bed fouling, etc.

In addition, corrosive contaminants can degrade amine strength, decrease gas treatment capacity, increase energy usage, and lower equipment life.

Seldom is a single contaminant responsible for amine system operating problems. These contaminants can include fine solid particulates, such as iron sulfides and liquid hydrocarbons in aerosol form.

Because of highly corrosive and contaminant laden environment, amine processes require an optimum filtration/separation system to operate properly.

Benefits of an Optimized Filtration System

An optimised filtration solution for Gas Sweetening includes three systems that are used at multiple points in the process:

1) Micro-DEP and Micro-LOK Series Coalescer Elements and Vessel

Ideally, this is used at four stages. At the beginning of the process, it's used to remove hydrocarbon, water, and other liquids and solids from sour gas feed, which reduces absorber foaming and fouling and increases absorption and carbon bed efficiency. Then it's used to remove carried over amine, water, and heavy hydrocarbons, which maintains fuel gas quality and protects downstream equipment.

At the end of the process, the filtration system is used to remove carried over amine and then remove water, amine, and liquid hydrocarbons. This protects downstream equipment and reduces maintenance and downtime costs at the sulfur recovery unit.

2) LiquiPleat Series Liquid Filter Elements and Vessel

This system is used in four places to remove scale and solid contaminants and protects the carbon filter system. This prevents carbon bed plugging, fouling in the reboiler and heat exchanger, and reduces foaming problems. Also, it removes carbon bed fines, which protects downstream equipment and prevents heat exchanger and reboiler fouling. This occurs again later to prevent fouling in the absorber.

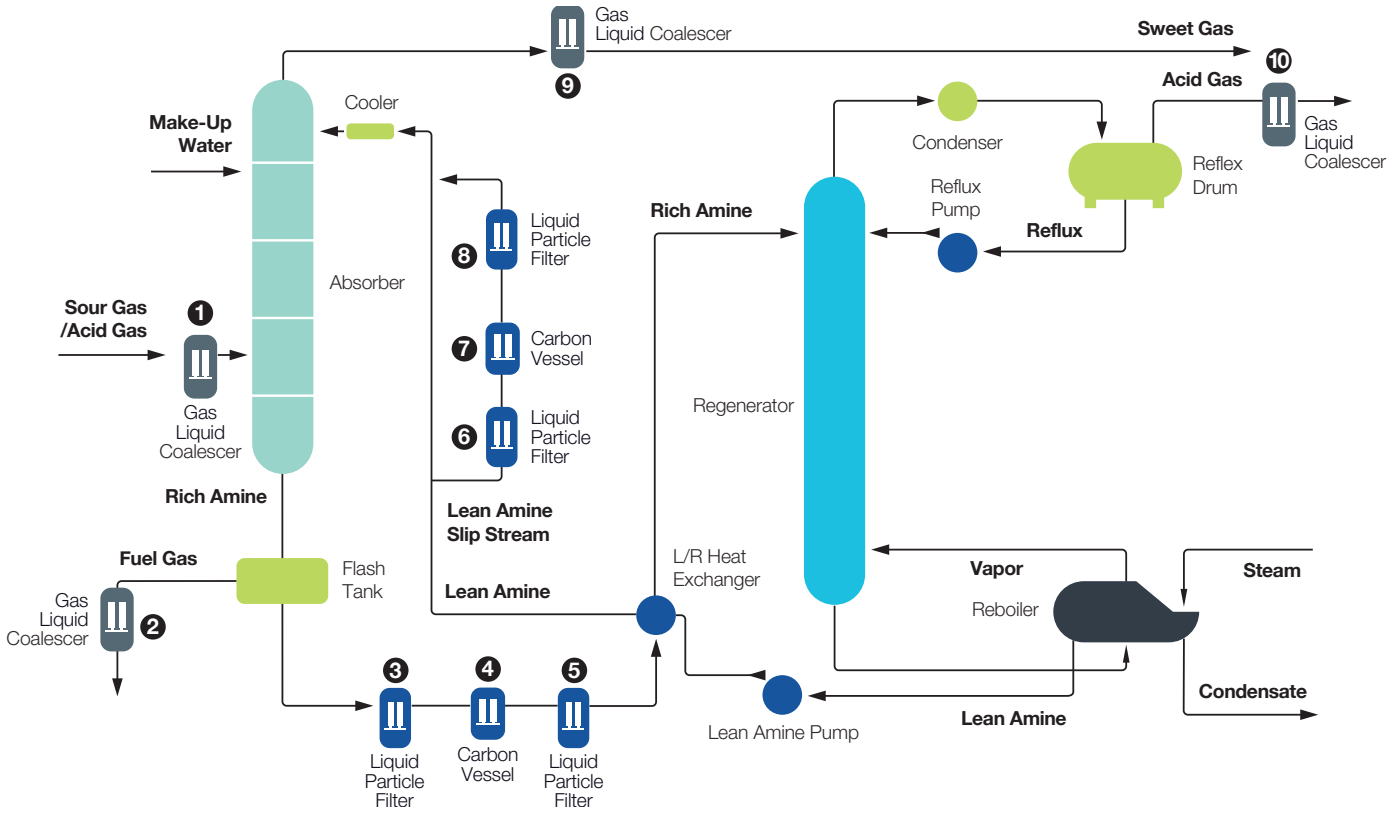
3) CarboPUR Series Activated Carbon Canisters

By removing dissolved organic acids produced by amine degradation and trace liquid hydrocarbons, it reduces amine foam in the regenerator (stripper) and degradation in the reboiler. It also reduces system corrosion and foaming tendency, and maintains solvent activity.

Together, this filtration solution offers the following benefits:

- Reduction of burner tip fouling
- Reduction in absorber (contactor) plugging
- Prevention of amine foaming
- Prevent amine carryover, which causes burner issues and affects the performance of the sulfur recovery unit.
- Reduces or eliminates foaming, which means less use of costly anti-foaming inhibitors
- Prevents reboiler fouling, thereby reducing energy consumption
- Increases carbon bed life
- Reduces amine consumption / loss
- Lowers operating and maintenance costs
- Improves contactor tower efficiency, with less carryover

Solutions for Gas (Amine) Sweetening Process



This schematic should be viewed as a general example of where filtration systems could be located within a Gas Sweetening Process. These processes will vary between companies and facilities. As such, each application should be reviewed and considered individually in order to choose the correct system technology.

- Inlet gas enters the bottom of the absorber/contactor column flowing upwards through a series of trays and is countercontacted with the aqueous amine solution absorbing the acid gas in the amine.
- Purified (sweet) gas exits at the top of the absorber/contactor column.
- Rich amine solution, which has H2S and CO2 molecules attached, leaves the absorber and flows to a flash tank then passes through a Lean/Rich cross exchanger to the upper section of the regenerator/ stripper column.
- The rich amine is heated in the regenerator/stripper column by contacting hot vapors from the reboiler causing the acid gas molecules to be stripped from the amine, thereby regenerating the solution.
- Steam and acid gases separated from the rich amine are condensed and cooled.
- The stripped acid gas typically flows to a sulfur plant for further processing.
- The condensed water is separated in the reflux accumulator and returned to the still.
- The hot lean amine from the reboiler is circulated back to the absorber/ contactor after passing through the lean/rich amine cross exchanger and a lean solution cooler.

	Filter Solution	Filter Purpose	Filter Benefit
01	Micro-DEP™ and Micro-LOK™ Series Coalescer Elements and Vessel	Removal of hydrocarbon, water, and other liquids and solids from sour gas feed.	Reduces absorber foaming and fouling, increases absorption and carbon bed efficiency.
02	Micro-DEP™ and Micro-LOK™ Series Coalescer Elements and Vessel	Removal of carried over amine, water, and heavy hydrocarbons.	Maintains fuel gas quality and protects downstream equipment.
03	LiquiPleat™ Series Liquid Filter Elements and Vessel	Removal of scale and solid contaminants and protect the carbon filter system.	Prevents carbon bed plugging, fouling in the reboiler and heat exchanger, and reduces foaming problems.
04	CarboPUR™ Series Activated Carbon Canisters	Removal of of dissolved organic acids produced by amine degradation and trace liquid hydrocarbons.	Reduces amine foam in the regenerator (stripper) and degradation in the reboiler.
05	LiquiPleat™ Series Liquid Filter Elements and Vessel	Removal of carbon bed fines.	Protects downstream equipment. Prevents heat exchanger and reboiler fouling.
06	LiquiPleat™ Series Liquid Filter Elements and Vessel	Removal of scale and solid contaminants including iron sulfites and protect the carbon filter system.	Reduces foaming problems, prevents carbon bed plugging, and prevents absorber fouling.
07	CarboPUR™ Series Activated Carbon Canisters	Removal of dissolved organic acids produced by amine degradation and trace liquid hydrocarbons.	Reduces system corrosion and foaming tendency, and maintains solvent activity.
08	LiquiPleat™ Series Liquid Filter Elements and Vessel	Removal of carbon bed fines.	Protects downstream equipment and prevents fouling in the absorber.
09	Micro-DEP™ and Micro-LOK™ Series Coalescer Elements and Vessel	Removal of carried over amine.	Protects downstream equipment and processes.
10	Micro-DEP™ and Micro-LOK™ Series Coalescer Elements and Vessel	Removal of water, amine, and liquid hydrocarbons.	Protects downstream equipment. Reduces maintenance and downtime costs at sulfur recovery unit.

Process 6: Hydrogen Production

Hydrogen is used in a wide variety of applications including electricity production, refining oil, chemical processes, and many more industrial uses. Due to the increased use of heavier crude oils containing higher amounts of sulfur and nitrogen to meet stringent emission standards, the need for hydrogen is experiencing rapid growth in the refining and chemical industries.

Many facilities will produce hydrogen as a by-product. For example, petrochemical plants release hydrogen as a by-product of their olefin production. Refineries produce by-product hydrogen from catalytic reforming of naphtha into higher value high-octane products.

However, hydrogen as a by-product will only meet a fraction of their needs. One of the primary forms of on-purpose hydrogen production is using Steam Methane Reformers (SMR). Refineries, industrial gas producers, and other chemical manufacturers all use the same SMR technology, which is 90% efficient in producing hydrogen.

How SMR works

The SMR process uses steam to produce hydrogen from a hydrocarbon source, such as natural gas. Methane reacts with steam under pressure in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. SMR is endothermic, meaning heat must be supplied to the process for the reaction to proceed.

Afterwards, in the water-gas shift reactor, the carbon monoxide and steam are reacted using a catalyst to produce carbon dioxide and more hydrogen. At this stage, the gas is approximately 75% hydrogen. After cooling, it then passes through the Pressure Swing Adsorption Unit to absorb the impurities, leaving essentially pure hydrogen. Left over tail gas is recycled as furnace fuel.

Benefits of an Optimized Filtration System

An optimised filtration solution uses three different systems at various stages to improve operation efficiency, protect downstream equipment and lower operating and maintenance costs:

1. GasPleat Series Pleated Gas Filter Elements and Vessel

This is initially used to remove liquid and solid contaminants from feed stock gas, which ultimately improves reforming efficiency, provides a longer service life, and reduced maintenance costs.

It is then used again to remove carry-over carbon fines and solid contaminants – essential to maintain hydrogen gas quality specifications.

2. LiquidPleat Series Pleated Liquid Filter Elements and Vessel

By removing solid contaminants from the make-up water, this system offers better heat transfer and process control, lower maintenance costs and optimum plant performance.

3. Micro-LOK or Micro-DEP Series Coalescer Elements and Vessel

This system is used to remove lube oil from compressor discharge gas, which enables more efficient hydrogen compressor operation, significantly reduced maintenance costs, and improved furnace operation.

Process 7: Catalytic

Catalytic reforming is a major process in the petroleum refinery and petrochemical industries. This process converts low octane naphthas into higher octane reformate products for gasoline blending and aromatics rich in benzene, toluene and xylene, with hydrogen and liquefied petroleum gas as a by-product.

With the fast-growing demand in aromatics and high-octane numbers, catalytic reforming is likely to remain one of the most important unit processes in the petroleum and petrochemical industry.

How catalytic reforming works

The most common type of catalytic reforming unit is semi-regenerative. It has three reactors, each with a fixed bed of catalyst, and all of the catalyst is regenerated in situ during routine catalyst regeneration shutdowns.

Some catalytic reforming units may have an extra spare or swing reactor allowing each reactor to be individually isolated so that any one reactor can be undergoing regeneration while the other reactors are in operation. When that reactor is regenerated, it replaces another reactor which, in turn, is isolated so that it can then be regenerated.

Common Problems

- Condensable hydrocarbons in both recycled and net hydrogen can reduce reliability of downstream equipment
- Liquid and solid contaminants in fuel gas lines may damage heater or furnace burner nozzles
- Lube oil contamination from compressor discharge line will decline reactor operations
- Liquid and solid contaminants will lower compressor operation efficiency
- Premature fouling and regeneration of reforming catalyst

Benefits of an Optimized Filtration System

There are lots of benefits to an optimised filtration system, including:

- Lower maintenance costs
- Longer burner service life
- Reduced catalyst contamination
- Enhanced reactor operations
- Improved operation and process efficiency

The key recommended filtration system throughout the catalytic process is the Micro-LOK or Micro-DEP Series Coalescer Elements and Vessel.

This system is used to:

1. Remove liquid and solid contaminants from fuel gas – improves burner efficiency, enables a longer service life, and reduces maintenance costs.
2. Remove condensable hydrocarbons from net hydrogen – protects compressor and downstream equipment.
3. Remove condensable hydrocarbons from recycled hydrogen – protects compressor, reduces catalyst contamination, and improves reliability.
4. Removes lube oil from compressor discharge gas – lowers maintenance costs and improves reactor efficiency.

Process 8: Isomerization

Many of the processes in a modern refinery are devoted to improving the octane value of chemical compounds used in blending gasoline. One important process is isomerization, which takes low-octane, normal-paraffins and chemically reshapes them into higher-octane, iso-paraffins. Isomerization complements catalytic reforming in upgrading the octane number of refinery naphtha streams.

Isomerization is a simple and cost-effective process for octane enhancement compared with other octane-improving processes. Light straight run (LSR) gasoline, which is mostly pentanes and hexanes, can have its octane number improved by the isomerization process which converts normal paraffins into their isomers. This results in a significant octane increase as normal pentane (nC5) has an octane number of 61.7, while its isomer, isopentane (iC5), has an octane number of 92.3. In a single-pass isomerization, the octane number of LSR gasoline can be increased from 70 to 84.

The isomerization process is also gaining importance in the refining industry due to limitations on gasoline benzene, aromatics, and olefin contents. The process upgrades the octane number of light naphtha fractions while reducing benzene content by saturation of the benzene fraction. Isomerate product contains very low sulfur and benzene, making it an ideal blending component in a gasoline pool.

Isomerization processes catalytically convert straight chain paraffin hydrocarbon molecules into isomers or branched molecules in a hydrogen rich environment that does not promote hydrocracking. The more complex branched isomers have a higher octane rating than the paraffin like hydrocarbons and are used as blending components in motor fuels.

Common Problems

- The first stage reactor outlet needs to be treated in a solid particulate filter to remove catalyst fines. Carry over of catalyst fines to second stage reactor will lead to catalyst fouling.
- The feed to the reactor coming off the Mol Sieve needs to go through a solid particulate filter to ensure that mol sieves fines are not being carried over to the reactor. Mol Sieve fines if carried over will plug the reactor and cause catalyst deactivation.
- Particulate and liquid aerosols cause premature fouling and regeneration of catalyst bed and reforming catalyst
- Catalyst fine contamination will foul stabilizer tower internals
- Condensable hydrocarbons in both recycled and net hydrogen can reduce reliability of downstream equipment
- Liquid and solid contaminants in fuel gas lines may damage heater/furnace burner nozzles
- Liquid and solid contaminants will lower compressor operation efficiency
- Lube oil contamination from compressor discharge line will impede on reactor operations

Benefits of an Optimized Filtration System

The key recommended filtration system throughout the isomerization process is the Micro-LOK or Micro-DEP Series Coalescer Elements and Vessel.

This system is used to:

1. Remove particulate and liquid aerosols from deisopentanizer tower - prevents unscheduled reactor downtime and extends catalyst bed life.
2. Remove liquid and solid contaminants from fuel gas – improves burner efficiency, enables a longer service life, and reduces maintenance costs.
3. Remove caustic liquids and particulate carryover – protects downstream equipment.
4. Remove liquids and solids from recycle hydrogen – ensures more efficient hydrogen compressor operation and significantly reduced maintenance costs.
5. Removes lube oil from compressor discharge gas – lowers maintenance costs and improves reactor efficiency.

The additional filtration system is the **GasPleat Series Pleated Gas Filter Elements and Vessel.**

This is used to prevent catalyst fines from entering the stabilizer, which prevents fouling of the stabilizer internals and helps it operate more efficiently.

Together, the filtration systems offer the following benefits:

- Enhanced reactor operation
- Extended catalyst bed service
- Longer burner service life
- Reduction in equipment fouling
- Lower operating and maintenance costs
- Improved operation and process efficiency

Conclusion

An optimised filtration system helps solve common contaminant management challenges experienced in key refining processes. When used at various stages of each process, the benefits of filtration systems are wide-ranging. However, the most important advantages are those that extend to the whole business:

- Extended life and ROI on process equipment
- Lower operating and maintenance costs
- Reduced downtime
- Improved process performance and operation efficiency

These benefits deliver a long-term impact on the bottom line.

Ultimately, no one solution works for all applications. No two refineries will have the same issues and challenges. Therefore, its critical to talk to the experts to identify the right solution for your application.

Filtration Group®
Process Technologies

ADDRESS

11607 E 43rd St N
Tulsa OK 74116

CONTACT

P: +1(844) GOFILTR
W: processtechnologies.filtrationgroup.com/en-US