

Filtration and Separations Technologies for Petroleum Refining

Understanding Root Causes... Finding Solutions

PALL CORPORATION

PR-900cEN



> Pall's products and services help optimize productivity, reliability, quality, safety, and environmental protection, while reducing overall operating costs.

FILTRATION AND SEPARATIONS TECHNOLOGIES FOR PETROLEUM REFINING

Pall helps refiners identify problems and apply solutions

The Refiners are constantly looking to increase production capabilities, reduce costs, and generate increased revenues and profits. To accomplish this goal, refiners regularly search for new ways to improve efficiency, while continuing to deliver high–quality products at profitable prices. Pall can play a key role in this continuous improvement process. Our products and services help optimize productivity, reliability, quality, safety, and environmental protection, while reducing overall operating costs.

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Pall understands the importance of improving these key business components. Success here can directly impact a refiner's bottom line.

The first step to continuous improvement is to identify problem areas and understand the root cause. After proper detection and documentation, Pall works to develop a solution to the problem that best utilizes our advanced separations and filtration technology.

We put decades of experience and know-how to work to design and implement long lasting solutions that enable refiners to:

- Meet tighter clean fuels product specifications
- Meet tougher environmental regulations
- Maintain or increase refinery throughput
- Lengthen run time
- Reduce maintenance

Pall Corporation maintains its position as the world leader in filtration and separations technology with a steady stream of innovative, high-quality products backed by excellent service and support. We invest heavily in R&D and technical service to provide the refining industry with exceptional returns on their investment.

Our filtration and separations solutions have been successfully deployed within refineries throughout the world.

Total Fluid Management℠

Pall follows a comprehensive, *Total Fluid Management* approach to identifying and solving contamination problems.

Our advanced technologies and services help refiners:

- Increase production
- Reduce unscheduled downtime
- Meet environmental emission standards
- Reduce corrosion rates, lengthen plant life, and improve safety
- Raise product yield and conversion
- Minimize product reprocessing
- Enable capacity expansion with minimum capital expense
- Help to debottleneck existing plants during revamps or clean fuels upgrades
- Help to utilize opportunity crudes
- Enable refiners to meet tighter product specifications
- Lower energy costs
- Lower maintenance costs
- Protect catalyst beds



Pall offers a full range of high-quality filtration and separations systems that meet the unique requirements of the diversified refineries that we serve. We design and manufacture nearly all of our media, elements, vessels, and fully integrated separations systems. By supplying the broadest array of polymeric, inorganic, metallic, and ceramic media available, Pall is able to select the optimal filter medium to meet specific process requirements.

In rare cases, where Pall does not have an appropriate product, we work with the customer to develop a new, customized product that cansolve the problem. We are eager to take on new challenges and are committed to keeping up with evolving market demands. Pall offers worldwide technology consultation and support through our Scientific and Laboratory Services (SLS) department. SLS is a worldwide network of scientists and engineers experienced in investigating and solving various and often complex problems encountered in fluid clarification and separation processes. In addition, a specialized group of scientists and engineers is solely dedicated to customers in the petroleum refining industry. Pall has state-of-the-art laboratories located throughout the United States, Europe, and Asia.

All Pall manufacturing facilities adhere to uniform manufacturing procedures and have been granted International Standards Organization (ISO) certification to ISO 9001. This ensures that Pall filtration and separation products and systems will perform exactly as specified, no matter where they are installed.

Root cause analysis and Total Fluid Management are the principles on which we base our success in the petroleum refining industry. We look forward to applying our knowledge, technology, and experience to help you achieve a higher level of process control and efficiency in your operations.



SLS test facility.

Filtration and Separation Recommendations

The process diagram and corresponding charts illustrate typical applications within a refinery.

Processes are detailed within the drawing and include major applications. The numbered items coincide with the recommended filter/separation application tables below. Note: should a particular concern or filtration/separation application arise that is not addressed in this brochure, please contact your local Pall representative for assistance.

Particulate Filters/Backwash Filters[1]

Application	Problem	Benefits
Aromatics 1	Liquid hydrocarbon and particulates cause foaming and fouling problems.	Reduced solvent losses and foaming; improved energy consumption; reduced maintenance, labor, and disposal costs.
Catalyst Protection 2	Solid particulates plug and deactivate catalyst bed and foul feed exchanger; water can deactivate some catalysts.	Improved conversion efficiency and profitability; fewer catalyst change-outs; improved conversion/yield; lower maintenance, labor, and catalyst costs; longer cycle times; less backwash fluid reprocessing; extended campaign life.
Final Product Filtration 3	Refinery final products contain particulates and water.	Improved product quality; fewer reprocessing and contamination costs; lower maintenance and disposal costs.
Fluid Catalytic Cracking Unit Slurry Oil 4	Catalyst fines reduce value of slurry oil.	Improved product quality and revenue; reduced critical nozzle erosion; increased yield; reduced coke formation in FCC reactor; less backwash fluid to reprocess; higher profitability of FCCU.
Rich / Amine Loop 5	Amine foaming.	Amine losses prevented; sulfur plant operation improved.

Blowback Filters[1]

Application	Problem	Benefits
Reduced Particulate Environmental Emissions 9a	Existing equipment is unable to meet tightening emission levels required by environmental authorities for particulate and micro-particle matter. Poor reliability of turbo expander and inability to meet desired FCC campaign length of 3-5 years between major repairs or overhaul of turbo expander.	Tougher environmental license limits met continuously and FCC plant shutdown and/or capacity reduction averted; turbo expander reliability improved dramatically.
CCR Recycle Gas 9b	Poor reliability of CCR recycle gas compressor; high maintenance costs; loss of expensive reformer catalyst.	Reliable CCR operation and production of H_2 and reformate.

Liquid/Gas Coalescers[1]

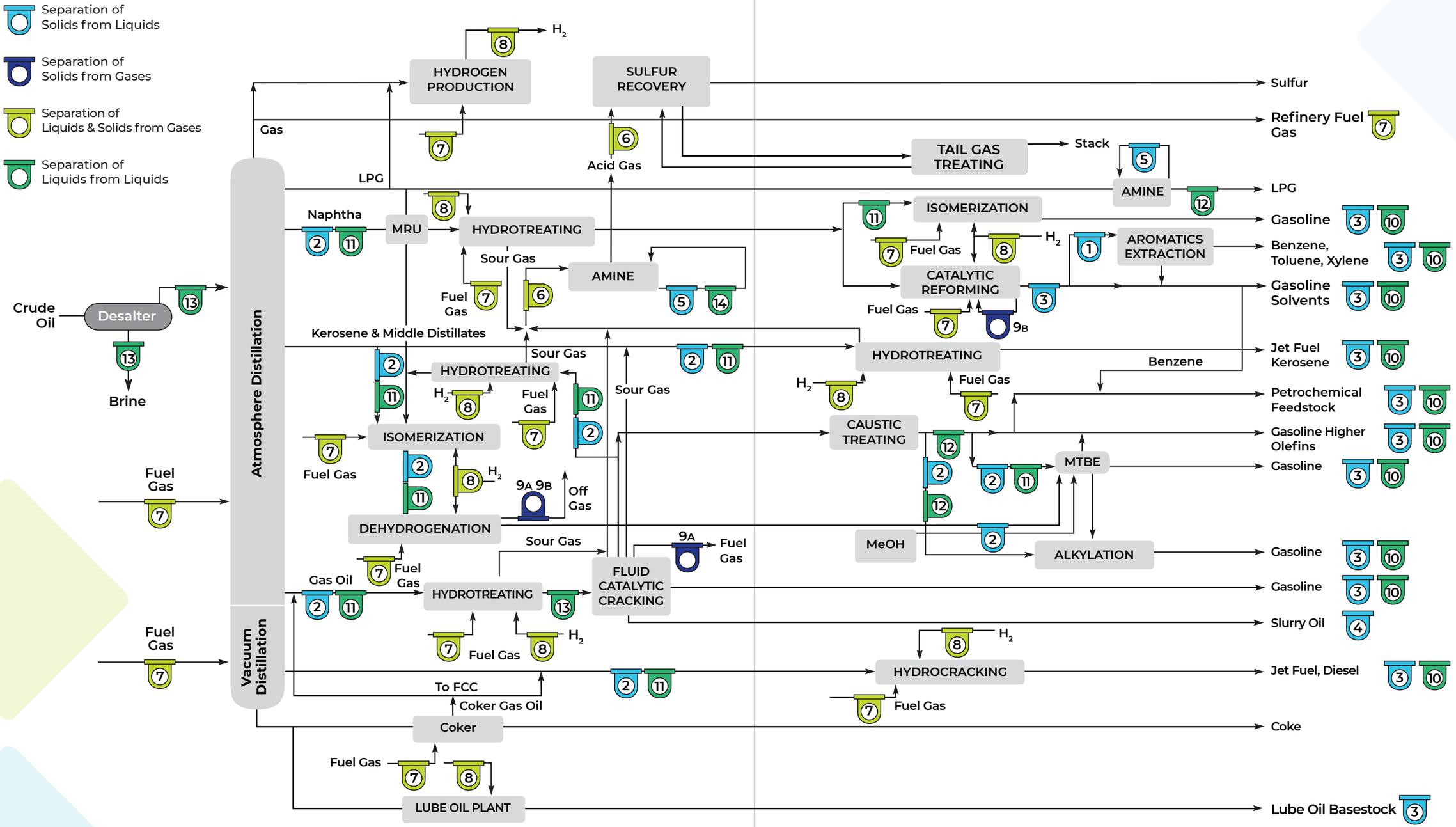
Application	Problem	Benefits
Amine and Sulfur Recovery Unit 6	Hydrocarbon carryover into amine plant causes foaming, excessive amine losses, and can lead to either reduced amine plant capacity or impact the ability to meet final product sulfur specifications in fuels. Amine plant upsets; sulfur plant trips; and environmental emissions above license limits.	Minimized or eliminated production losses due to sulfur plant trips; reduced environmental license level exceedance; stable amine plant operations; and increased amine plant capacity.
Refinery Fuel Gas 7	Fuel gas composition changes rapidly and contains condensable hydrocarbons; liquids and solids will foul, plug burners and combusters; low NOx and ultra low NOx burners are especially sensitive to plugging.	Reduced or eliminated routine burner cleaning program; improved furnace fine tuning; reduced fuel gas usage; reduced greenhouse gas emissions; safer furnace operation and on-spec NOx emissions.
Hydrogen Compressor Protection 8	Liquid hydrocarbons and solid contaminants such as corrosion products or ammonium chloride in hydrogen gas streams can lead to premature failure of reciprocating compressor suction and discharge valves, and piston ring failure resulting in H_2 compressor downtime and excessive unscheduled maintenance and in some cases can cause lost production.	Reliable hydrogen compressor operation; significantly reduced maintenance and repair costs.

Liquid/Liquid Separators[1]

Application	Problem	Benefits
Final Product Filtration 10	Off-spec products; high salt or clay tower usage; corrosion in storage tanks.	Improved product quality/on-spec products; fewer reprocessing and contamination costs; lower maintenance and disposal costs; free up tank storage; improved cash flow and fewer delayed shipments.
Catalyst Protection 11	Water may contain caustic and other solid particulates; plug or deactivate catalyst bed.	Improved conversion efficiency and profitability; fewer catalyst change-outs; lower maintenance, labor, and catalyst costs.
Treating 12	Caustic or amine carries over into product stream causing off-spec product; carried-over caustic can disarm sensitive catalyst.	Improved profitability; lower reprocessing costs; reduced maintenance and labor costs.
Desalter 13	Desalter upsets can cause oil carryover to waste treatment plant and upset water treatment plant operation and emissions to the environment; desalter upsets or crude charge rate increase can cause brine carryover to CDU and result in high corrosion rates in crude overhead; salt in FCC feed can reduce FCC catalyst yield and shorten catalyst life.	Less emissions from water treatment plant; allows debottle-necking of desalter and reduced corrosion rates in CDU overhead; improved FCC catalyst yield and longer FCC catalyst life.
Amine Unit Protection 14	Liquid hydrocarbon ingress; foaming incidents; upsets at sulfur plant.	More stable Amine system operation, reduced foaming, longer A/C life; less sulfur plant trips.

[1] In applications where different options are listed, Pall Corporation will assist project engineers in determining the best filtration solution for their situation.

Refinery Filtration and Separation Applications

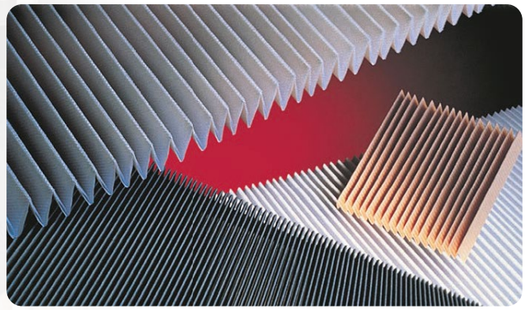




Products that Meet Refiners' Needs

With an extensive portfolio of filtration and separation products, Pall can help refineries improve fluid quality and increase profitability by optimizing the performance of their processing equipment. Many of Pall's products were developed specifically for the refinery industry, in collaboration with our customers.

Our close relationship with refiners and process licensors has helped Pall understand current and future needs. Our awareness and dedication to this market has fueled our product development programs and sharpened our technical and scientific skills. As a result, Pall is continually introducing new products to help improve the production and efficiency of our customers' operations.



At the heart of every filtration and separation system is the medium which performs the separation. Pall manufactures 21 distinct families of media, providing over 150 grades of polymeric, inorganic, metal, and ceramic filter products and phase separation systems. This allows Pall to supply high-quality products with the appropriate medium and grade for specific refinery applications.

Pall's advanced technologies include:

- **Separation of Solids from Liquids**
- **Separation of Solids from Gases**
- **Separation of Liquids and Solids from Gases**
- **Separation of Liquids from Liquids**

Details of each technology can be found in the sections that follow.

Liquid Disposable Filters

Pall's high performance disposable filtration solutions efficiently remove solid contamination from liquid streams. Disposable filters can be used to remove solids from finished refinery products and from solvents such as amine and sulfolane.

Pall's disposable filters are characterized by high dirt-holding capacity and lot-to-lot uniformity. Our filters provide long service life and improved protection for equipment and personnel. They are designed to prevent both unloading of trapped particles and media migration. The filters are selfaligning in Pall's vessels, with positive sealing to eliminate fluid bypass.

Benefits of Pall's Disposible Filters

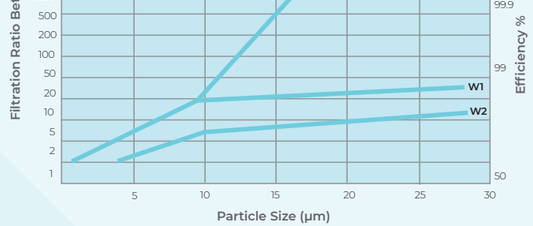
- Gradient of pore sizes for full utilization of the filter
- Strength and durability to withstand changing process conditions
- Chemical and thermal compatibility with process conditions to ensure long life
- Absolute-rated[3] for reliable, reproducible performance backed by documented performance data
- Cost-effective, nominally-rated filters are available for less critical applications

[3] An absolute rating is defined as Bx=5000 as measured utilizing the widely accepted modified OSU F-2 test.

Performance Comparison - Profile II Filters vs. Competitive Depth Filters

	Filter Brand		
Particle Size (µm)	Profile II Filter (P200) 20 µm Absolute $\beta_{x,20}$ = 5000	W1 Wound Filter 1 µm Nominal β_1 = 1	W2 Spun Depth Filter 1 µm Nominal β_1
	Percent Removal Efficiency		
0.5	NA	NA	NA
1	NA	NA	NA
2	<50%	<50%	<50%
4	75%	75%	50%
10	95%	95%	87.5%
25	>99.98%	96.7%	93.3%
50	>99.98%	98%	96%

Filtration Beta Ratio Comparison - Profile II Filters vs. Competitive Depth Filters



Filtration beta ratio of Profile II filters (P200) and two competitive polypropylene depth filters rated at 1 µm nominal.

Liquid Disposable Filters

Pall provides high-performance disposable liquid filtration solutions engineered to reliably remove particulate contamination across refinery processes, including critical solvent systems such as amine units. These technologies deliver consistent, absolute-rated performance that protects equipment, stabilizes operations, and reduces overall maintenance costs.

Solvent filtration

Pall advanced liquid filtration solutions leverage high performance absolute rated products to ensure equipment protection. Within the refinery amine unit the removal of fine solids can offset foaming issues, reduce solvent degradation, and present the fouling of heat exchangers and downstream equipment, enabling a more stable operation and improved throughput.

Final product polishing In final product filtration, Pall's disposable liquid filters ensure consistent removal of fine particulate contamination to meet stringent product quality specifications for transportation fuels and other refined products. By delivering reliable, absolute-rated performance, these systems protect downstream storage, transfer, and distribution infrastructure while minimizing offspec risk. Optimized for high flow rates and extended service life, Pall's solutions help refiners reduce changeout frequency, lower operating costs, and maintain stable, predictable product quality across varying process conditions.





Equipment Protection

Pall filtration solutions play a critical role in protecting refinery equipment by removing particulate contamination that drives fouling, corrosion, and mechanical wear across key assets such as heat exchangers, pumps, and transfer systems. By maintaining low contaminant levels, these systems help preserve heat transfer efficiency, reduce unplanned maintenance, and extend equipment run life, enabling more reliable operation and improved overall plant performance.

- **Controls solids that contribute to heat exchanger fouling and reduced thermal efficiency**
- **Minimizes corrosion and wear in pumps and rotating equipment caused by particulate ingress**
- **Improves run length and reduces unplanned downtime through consistent contamination control**

Catalyst Protection

Pall's liquid filtration solutions play a vital role in protecting refinery catalysts by removing fine particulate contamination that can lead to premature deactivation and increased reactor pressure drop. By delivering consistent, absoluterated filtration upstream of critical units, Pall systems help maintain clean feed conditions, reduce fouling in reactor beds, and extend catalyst life. This results in longer campaign lengths, improved process stability, and reduced operating costs through fewer shutdowns and catalyst changeouts.

SEPARATION OF SOLIDS
FROM LIQUIDS

Liquid Disposable Filters



Profile II Filters

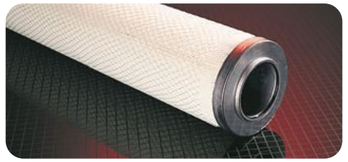
Profile II filters are available in polypropylene, nylon or polyphenylene sulphide (PPS) media. These elements have an upstream continuously graded pore section and a downstream absolute-rated section, which increases service life many times.

These filters are suitable for a wide range of applications, involving both corrosive and non-corrosive fluids. Profile II filters are ideal for prefiltration and final filtration.



Profile Coreless Filters

Profile Coreless filters are absolute-rated filters used to filter gases or liquids. They have high capacity, low cost, and are ideal for applications such as amine loop filtration, compressor protection, or final product filtration. The coreless construction allows for easy and safe filter incineration and disposal.



Ultipor GF Plus Filters

The Ultipor GF Plus medium consists of resin-bonded glass fibers supported by upstream and downstream polymeric substrates. This unique construction provides for a strongly bonded, migration-free, high dirt-holding capacity medium. Ultipor GF Plus filters are used successfully in a variety of refinery applications.



Claris Filters

Claris filters are polypropylene melt blown filters. Claris filters feature an E-core, Extruded Fibrous Core, structure which provides excellent strength. Their gradient pore structure enhances their dirt-holding capacity. Claris filters feature an all polypropylene construction for easy and safe filter incineration and disposal.



HDC II Filters

HDC II filters are constructed of all polypropylene pleated media. These filters feature a high area, high dirt-holding capacity, and extended service life. HDC II filters are ideal for use in applications where economy and reliability are crucial.



Epocel Filters

Epocel filters have a pleated, high-area construction which provides long service life and consistent production. Constructed of epoxy-resin-impregnated cellulose, this fixed-pore construction eliminates unloading and media migration. Epocel filters provide a broad range of chemical compatibility and are recommended for the clarification of a wide range of fluids and gases.



Vector High Flow Filters

Vector high flow filters are engineered for high capacity) coarse particulate removal in demanding refinery applications. Leveraging Pall's proprietary Ultipleat laid over pleat design) they deliver high flow rates per element and up to **X** longer service life than conventional filters) reducing changeout frequency and dointime. Their large diameter) coreless design enables efficient system operation) while the inside to outside flow pattern retains contaminants during changeout supporting cleaner processes and reliable protection of downstream equipment.

Liquid Disposable Filters



Duo-Fine Filters

Duo-Fine filters are high-capacity pleated filters with microfiberglass media. The microfiberglass media provides exceptional dirt-holding capacity for long service life.

Duo-Fine filters are available in a variety of core options to satisfy a wide-range of temperature compatibilities.



Ultipor HT Filters

Ultipor HT filters are pleated, high area elements designed for long service life. The unique medium structure is a high temperature composite. The filters are qualified for use up to 218 °C/425 °F with compatible fluids.

Designed specifically for high temperature applications and well suited for many refinery applications, these high temperature filters are used to process tough oil fractions, containing fine suspended solids typically found in processes related to desulfurization and fuels upgrading. Filter operability at high temperatures can often mean elimination of intermediate tanks for product cooling and save energy on product reheating costs upstream of the hydroprocessing units.



Nexis Filters

Nexis high-efficiency depth filters are manufactured using an advanced, microprocessor-controlled, Co-located Large Diameter (CoLD Melt™) production process. This proprietary process allows the creation of multiple filtration zones within a single filter cartridge. The benefits include: efficient contaminant removal, long service life, and improved strength.



Ultipleat High Flow Filters

Ultipleat High Flow filters are coreless, large diameter, single open-ended, pleated filters with an inside-to-outside flow pattern. These filters utilize Pall's proprietary, crescent-shaped pleats and are available in a range of materials. The Ultipleat High Flow filters come in diameters of 152.4 mm (6 in) and lengths from 5082023 mm (20-80 in). Ultipleat High Flow technology enables the use of considerably fewer filters and smaller housings for high flow rate applications.



Marksman Filters

Marksman filters are available as high-capacity, pleated, depth filters or high-capacity melt blown filters. These filters feature a large 152.4 mm (6 inch) diameter, high surface area, and high flow capacity. Marksman filters are available in a variety of grades and sizes to meet specific application requirements.



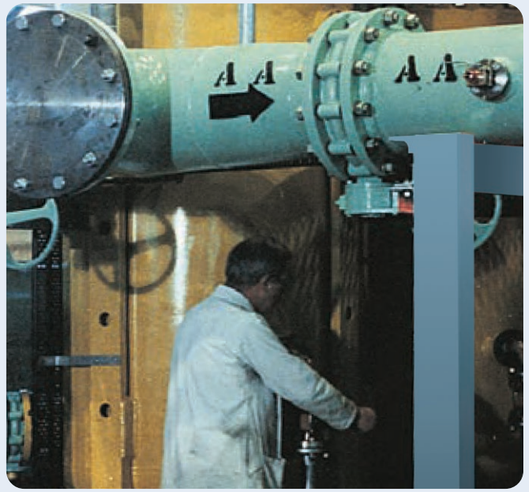
Profile UP Filters

The unique Ultipleat (U) crescent-shaped construction of the Profile (P) depth filter provides longer life than most pleated polypropylene filters. Optimized for the removal of gels and other viscous fluids, the Profile UP depth filter provides excellent chemical compatibility with low extractables. These filters are the appropriate choice for a wide range of applications in the refining industry.

Separation of Solids from Gases

Pall continually develops state-of-theart technology for solid/gas separation to deal with aggressive environments, extreme temperatures, and high contaminant concentrations. Pall has worked with both refiners and process licensors to develop blowback systems that efficiently separate solid particulates from gas streams.

A filter medium with sufficiently small pores is selected for this application. Solids form a permeable cake on the filter's surface that is dislodged at a predetermined pressure drop (a function of cake thickness and compressibility) by initiating a reverse pulse (blowback). The dislodged solids are purged from the filter system, where they may be returned directly to the process for reuse, or removed from the process stream and sent to a storage or collection unit. The filter is then returned to full forward flow and to an initial pressure drop that remains essentially constant through repeated blowback cycles.



Pall's blowback filter system in operation.

Blowback Filters

- PSS sintered powder stainless steel filters
- PMF metal fiber filters
- Rigimesh sintered woven wire mesh filters

Gas Particle Disposable Filters

- Pall pleated filters with Ultipor GF Plus medium, HDC II medium, or Epocel medium
- Ultipleat filters with Profile depth filter media
- Profile II filters
- Profile coreless filter

Blowback Systems vs. Other Technologies

	Pall Blowback Filters	Cyclone	Baghouse	Scrubber	Electrostatic Precipitator
Efficiency of Solid Separation from Gas Stream	**>99.99%**	98%	99.9%	99%	99%
Separation Efficiency Varies with Solids Loading	**No**	Yes	No	Yes	Yes
Relative Operating Pressure Drop	**Medium**	Medium	Medium	High	Low
Maximum Operating Temperature	**899°C (1650°F)**	1093°C (>2000°F)	232°C (450°F)	232°C (450°F)	482°C (900°F)
Sensitivity to Changes in Flow Rate	**Insensitive**	Very Sensitive	Some Sensitivity	Very Sensitive	Very Sensitive
Precooling Required Upstream of Solid Separation Device	**No**	No	Yes	Yes	Yes
Solids-Loading Reduction Prior to Final Separation Required	**No**	No	Yes	Yes	Yes
Reliability and Safety of Operation	**High**	High	Low	Medium	Medium

Pall's blowback systems use either porous metal composite or ceramic filters. The comprehensive capabilities of Pall's blowback systems are highlighted in the chart above.

Blowback Filters



PSS Porous Metal Filters

Manufactured of sintered stainless steel powder, the PSS “S” medium offers exceptionally uniform permeability and absolute removal efficiencies.

PSS elements are produced with advanced quality and performance with a high void volume (up to 60% in some grades). This provides high dirtholding capacity and low pressure loss, especially in fine grades, which permit design at high flux to help reduce capital costs.



PMF Metal Fiber Filters

PMF filters are manufactured of fine diameter 316L stainless steel fibers that are sintered at their points of contact to produce a uniform, strong, tapered-pore medium. This medium provides exceptionally high dirt-holding capacity, with one or more inner layers providing absolute-rated filtration.



Rigimesh Stainless Steel Woven Wire Mesh Filters

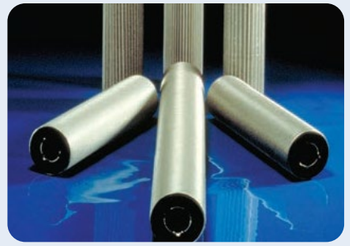
Pall’s proprietary process permits the use of finer-diameter wires in the manufacturing of Rigimesh stainless steel woven wire mesh filters. The result is low pressure drops, more pores per unit area, and high dirt-holding capacity.

The medium is sintered for improved tensile, yield, shear, and fatigue strength. Rigimesh filters maintain a uniform pore size and exhibit no media migration, even under high temperature and pressure conditions.



Dia-Schumalith® Ceramic Filters

Dia-Schumalith ceramic filters are better suited for applications requiring higher temperatures and greater corrosion resistance than most sintered metal alloy filters. The silicon carbide support body and alumina membrane of the Dia-Schumalith filter ensures a low differential pressure at high flux rates.



Dynalloy® Stainless Steel Filters

Dynalloy filters are made of depth-type, stainless steel fiber media manufactured under strict ISO 9001 quality control measures.

Fabrication begins with the manufacturing of discrete micron size fibers. A uniform mat of these fibers is constructed in a randomly laid orientation. The mat is compacted and sintered (metallurgically bonded) to provide strength and integrity. The result is a high void volume, closely controlled pore size media ideal for corrosion-resistant applications.

SEPARATION OF SOLIDS
FROM GASES

Gas Particle Disposable Filters



HDC II Filters

HDC II filters are constructed of all polypropylene pleated media. These filters feature a high area, high dirt-holding capacity, and extended service life. HDC II filters are ideal for use in applications where economy and reliability are crucial.



Epocel Filters

Epocel filters have a pleated, higharea construction which provides long service life and consistent production. Constructed of epoxyresin-impregnated cellulose, this fixed-pore construction eliminates unloading and media migration. Epocel filters provide a broad range of chemical compatibility and are recommended for the clarification of a wide range of fluids and gases.



Ultipor GF Plus Filters

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Profile II Filters

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Profile Coreless Filters

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Ultipor HT Filters

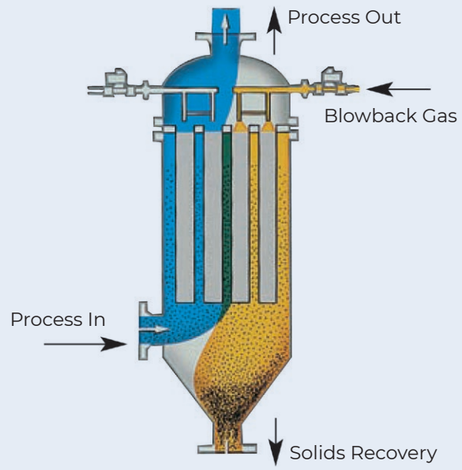
Ultipor HT filters are pleated, high area elements designed for long service life. The unique medium structure is a high temperature composite. The filters are qualified for use up to 218˚C/425˚F with compatible fluids.

Jet Pulse Blowback Method

The jet pulse blowback method eliminates the need for large vessel isolation valves.

Full forward flow is maintained at all times. Groups of elements are blown back sequentially by directing a highpressure pulse of gas into the throat of each element. The pulses last between 0.1 and 1.0 seconds, at two to three times the process pressure. During this period, the flow to the elements being cleaned is reversed momentarily by a high-pressure jet pulse. The shock wave set up by the reverse pulse, enhanced by the venturi in the element throat, effectively removes the accumulated cake from the elements.

Pall's Blowback System



- One or more vessels
- Full forward flow maintained
- Groups of elements blowback sequentially
- Forward flow overcome by highpressure pulse in reverse flow. Short duration (0.1 to 1.0 seconds)



Pall's blowback filters are used to remove catalyst fines from vent gas.

SEPARATION OF SOLIDS
FROM GASES

Pall's blowback systems are used in many applications. A few of the more common ones are listed below.

Catalytic Reforming

Pall's blowback systems are used in catalytic reforming units where catalyst is continuously regenerated to protect against erosive wear and fouling of the recycle gas compressor. These systems filter the elutriation gas that is recycled back to the regenerator. For this application, Pall's PSS porous stainless steel filters (rated one micron in gaseous service) with jet pulse (blowback) in-situ cleaning are used. PSS filters have been installed successfully at refineries throughout the world.

Catalytic Cracking

Blowback systems used to remove catalyst fines from FCC flue gas allow the refiner to:

- Meet emission guidelines
- Fully protect downstream process equipment

The current permissible particulate emission for a fluidized-bed catalytic cracker (FCC) globally is <50 mg/Nm³ . This mark is moving to <40 mg/Nm³ for the world, and in some cases as low as 10 mg/Nm³ for given countries.

Depending upon the economics at a specific refinery, there are several blowback options:

A. Where turbo expanders are in service – a hot gas filter is recommended upstream of the expander to maintain maximum power recovery and extend turbine blade life.In hot gas applications (up to 850°C/1560°F) as related to coal gasifiers and fluid bed coal combustorswith an even more corrosive and hotter environment than FCC, Pall's PSS porous stainless steel filters or DiaSchumalith ceramic filters have proven to be efficient and reliable. Unlike cyclones, the removal efficiency of Pall blowback filters remains constant during variations in gas flow rate.

B. If turbo expanders are not used – PSS clean-in-place blowback filters are recommended to consistently meet emission guidelines.The removal efficiency of PSS filters remains constant during flow surges (upset conditions) and is not affected by changes in the electrostatic charge of the particulate matter, as is the case with electrostatic precpitators.

C. If third- and fourth-stage cyclones are in place, replacing the fourth-stage with PSS filters will improve solids capture, which may be sufficient to meet emission guidelines with minimum capital investment. The use of fourth-stage blowback filters has proven to be the most cost-effective way to meet <50 mg/Nm3 emissions in FCC flue gas applications.

D. FCC hopper vent filters can be used to reduce fugitive emissions during catalyst loading/unloading and transfer.



Filter tubesheet assembly installation

Dehydrogenation Processes

PSS porous stainless steel filters process the catalyst regenerator off-gas at dehydrogenation plants operating fluid bed reactors. Pall's blowback system reduces particulate emissions in a single step, to levels at or below regulatory guidelines. Older plants had used two stages of cyclones followed by flue gas scrubbers to reduce such particulate emissions.

Separation of Liquids and Solids from Gases

Pall's SepraSol™ liquid/gas (L/G) coalescers have been used in refineries and gas processing plants for more than thirty years.

Pall's liquid/gas coalescers provide maximum liquid and solid removal at low saturated pressure drops to reduce maintenance and operating costs associated with contaminated gas. The element's highly effective filtration area and glass fiber resin-bonded pleated cartridge construction is surrounded by non-woven polymeric support and drainage layers. The coalescer is rated at 0.3 µm (99.99% removal efficiency) for solid particles, and produces downstream liquid aerosol concentration as low as 0.003 ppmw. These specifications ensure long service life, minimized operating costs and minimal labor requirements, as well as greatly improved equipment reliability.

Pall's liquid/gas coalescers merge, or coalesce, small droplets of liquid into larger drops. A gas is forced to flow through several layers of filter media, each layer having a progressively larger mean pore opening. As droplets compete for the open pores, they coalesce, and the process continues until the larger drops continually collect and drain into a collecting sump.

Pall's liquid/gas coalescers remove virtually all liquids in gas streams (down to 0.003 ppmw liquid in the effluent gas). In addition, Pall's liquid/gas coalescers have a proprietary oleophobic/hydrophobic treatment that ensures efficient removal and quick recovery from process upsets that send slugs of liquid downstream.

Liquid/Gas Coalescers

- SepraSol liquid/gas coalescers
- SepraSol Plus liquid/gas coalescers
- SepraSol Double Open-ended liquid/gas coalescers



Pall's liquid/gas coalescers remove liquids and solids from hydrogen and fuel gas, protecting turbo machinery and combustion equipment.

Liquid/Gas Coalescers vs. Other Technologies

	SepraSol High Efficiency L/G Coalescer	Mist Eliminator	Vane Separator	Cyclonic Separator	Knock-out Drum
Smallest Liquid Droplet Efficiently Removed (Micron)	**<0.1**	5	10	10	300
Relative Operating Pressure Drop	**Low**	Medium	Medium	Medium	Low
Sensitivity to Increased Liquid Loading	**Low**	High	Medium	Medium	Medium
Sensitivity to Increased Flow Rate	**Medium**	High	Medium	Medium	Medium
Sensitivity to "Turn-Down"	**Low**	High	High	High	Low

SEPARATION OF LIQUIDS
AND SOLIDS FROM GASES

Pall's liquid/gas coalescers are used in many applications. A few of the more common ones are listed below.

Hydrogen Recycle Gas Compressor Protection

Pall's liquid/gas coalescers are installed in front of hydrogen compressors to prevent costly unscheduled downtime. Refiners have been able to extend regular maintenance schedules by installing liquid/gas coalescers upstream of the compressors. Because refinery hydrogen streams are particularly prone to changes in purity and liquid concentration, Pall's oleophobic/ hydrophobic treatment is extremely beneficial in this application.

Burner Protection

Liquid and solid contamination in fuel gas streams is a universal problem for refineries. By removing such contaminants, liquid/gas coalescers significantly reduce the maintenance associated with plugged burner tips in process furnaces. Low NOx and Ultra Low NOx burners are even more susceptible to plugging. Because the concentration of liquids in fuel gas can change instantaneously, Pall's oleophobic/hydrophobic treatment again is particularly beneficial.

Lube Oil Recovery

Most compressors have an oil lubricating system. Lube oil is often discharged into the process gas in aerosol form. A liquid/gas coalescer placed at the discharge of a compressor will recover the lube oil and prevent contamination of downstream catalyst, desiccant, and activated carbon beds.

Molecular Sieve / PSA Protection

Most mol sieves or PSA's used for drying process streams are sensitive to free water which increases regeneration frequency and reduces the life of adsorbents. SepraSol L/G coalescers are recommended to protect mol sieves / PSA's on isomerization units, polypropylene units or in hydrogen plants for hydrogen purification.

Gas Treating Processes / Sulfur Recovery

In amine treating units, foaming can be initiated by liquid hydrocarbon contaminants in the feed gas. Installation of a liquid/gas coalescer upstream of the amine contactor can reduce the costs associated with foaming such as reduced processing capacity and increased amine losses. Liquid/gas coalescers can also recover any amine that is carried over into the acid gas going to the sulfur plant or the sweet gas. By reducing upsets in the amine plant, the sulfur plant can be protected from upsets and the number of trips or incidences of off-spec sulfur can be reduced along with a reduction in environmental emissions.

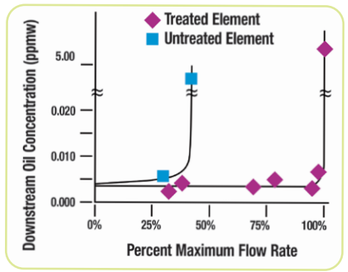


Liquid / Gas Coalescers for Optimum Performance

Pall's liquid/gas coalescers perform with maximum removal efficiency and economy that reduces equipment downtime, labor and maintenance costs. Pall's unique filter medium provides single-stage coalescing, separating liquid aerosols smaller than 0.1 micron in size. Pall's proprietary coalescer treatment improves the drainage of liquids through the coalescer, enabling the use of smaller assemblies and minimizing up-front capital costs. The treatment also lowers operating costs by operating at a lower liquid saturated pressure drop and by recovering quickly from process upsets.

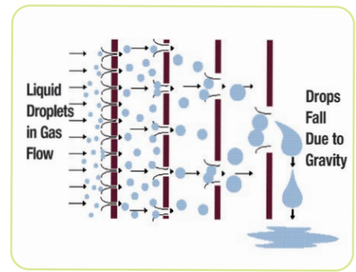
Effect of Chemical Treatment on Coalescer Performance

Chemically treating the medium can significantly increase the flow per cartridge.



Coalescing Mechanism

Small droplets coalesce to form large droplets.



Separation of Liquids from Liquids

When refinery customers alerted Pall to recurring problems with hazy fuel and caustic carryover, Pall worked with them to provide a long-term solution.

As a result, Pall developed two new products – the AquaSep® liquid/liquid coalescer and the PhaseSep® liquid/liquid coalescer. Pall consulted with its customers during every step of the product development cycle to ensure that the new products would meet their needs.

Today, AquaSep Plus coalescers and PhaseSep coalescers are installed in refineries throughout the world and are used in a variety of applications including:

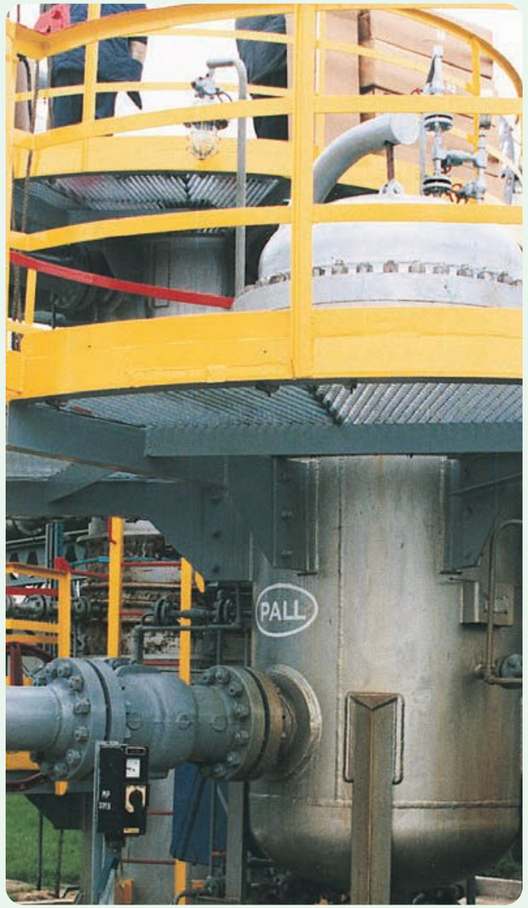
- Removal of water from gasoline, diesel, kerosene, and jet fuel
- Protection of catalysts and adsorbents from water contamination
- Removal of carried-over caustic from caustic treating processes
- Removal of carried-over amine from LPG
- Removal of H/C from amine
- Protection of salt driers and clay towers

Pall's AquaSep Plus coalescer and PhaseSep coalescer are multiple-stage systems. These systems first remove particulate matter, then coalesce and separate the water or liquid contaminant from a hydrocarbon stream. An AquaSep Plus coalescer or PhaseSep coalescer can remove entrained water to a level at or below 15 ppmv.

Pall's PhaseSep liquid/liquid coalescer has been demonstrated to reduce the sodium concentration downstream of a caustic treating unit to below 0.5 ppmw of sodium. In addition,Pall's liquid/liquid coalescers do not disarm in the presence of surface active agents in the fuel.

Liquid/Liquid Coalescers

- AquaSep Plus liquid/liquid coalescers
- PhaseSep liquid/liquid coalescers
- Small flow liquid/liquid coalescers
- Lucid™ liquid/liquid separators



Pall's AquaSep Plus and PhaseSep coalescers are the most cost-effective technology for liquid/liquid separation compared to other methods, including tank settling, electrostatic precipitation, salt drying, sand filtration, and coalescing by mesh pads.

SEPARATION OF LIQUIDS
FROM LIQUIDS

Unique Stack Design

Pall's AquaSep Plus coalescers and PhaseSep coalescers are stacked on top of a separator element. This proprietary stacking method optimizes the flow distribution from the coalescer to the separator, ensuring that each separator has equal flow. In conventional two-stage systems, the separators are located at different distances from the coalescer, causing unequal distribution of flow to the separator. Also, conventional twostage systems require several coalescer elements for each separator. Pall's stack design results in an overall smaller assembly size and a longer coalescer/separator life.

Low Interfacial Tension (IFT)

The ability to remove water improves as the IFT between the two phases increases. The IFT effectively measures the stability of an emulsion or dispersion. The IFT is a critical factor when considering liquid/liquid coalescence because the largest possible stable droplet size that will form by the coalescence process will be dictated by IFT. A system with a high IFT (> 20 dyne/cm) can sustain a large stable coalesced droplet size. Systems with low IFT (i.e., water in fuels with additives < 20 dyne/cm) form smaller stable coalesced droplets and require a high-efficiency coalescer/separator.

Disarming

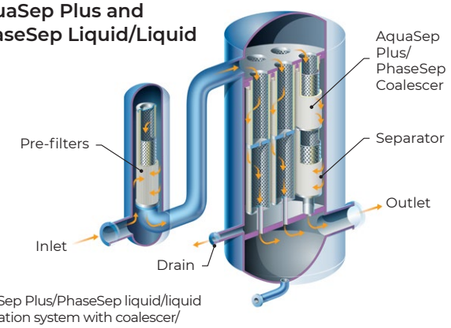
Surfactants in fuels have a tendency to form fuel/water hazes and can degrade the performance or disarm conventional glass fiber coalescers. Pall's liquid/liquid coalescers do not contain glass fiber, instead they are constructed of polymeric material using a unique proprietary process. This results in a long, reliable, low-maintenance service life when compared to conventional liquid/liquid coalescers. Pall's liquid/liquid coalescers are immune to disarming caused by surface active components like naphthenate or sulfonate carryover, or the addition of corrosion inhibitors, dispersants, and static dissipators.

AquaSep Plus Liquid/Liquid Coalescers and PhaseSep Liquid/Liquid Coalescers



AquaSep Plus liquid/liquid coalescers and PhaseSep liquid/liquid coalescers were developed to efficiently separate very stable liquid/liquid dispersions and provide high-fluid quality and value. They are compatible with highly acidic and basic fluids. The high-performance stack design allows an even flow distribution which permits a high flow rate in a smaller assembly. Also, the long life of the cartridge results in fewer change-outs, which reduces maintenance and disposal costs.

AquaSep Plus and PhaseSep Liquid/Liquid



AquaSep Plus/PhaseSep liquid/liquid separation system with coalescer/ separator stack in a vertical housing.

Liquid/Liquid Coalescers vs. Other Technologies

	Pall AquaSep Plus/ PhaseSep System	Salt and Desiccant Tower	Conventional Coalescers	Pack Bed Tower	Electrostatic Precipitator	Tank Settling
Lowest Interfacial Tension Efficiency Separated	**AquaSep Plus: 3 dyne/cm PhaseSep: <2 dyne/cm**	<2 dyne/cm	>20 dyne/cm	>20 dyne/cm	>10 dyne/cm	>20 dyne/cm
Relative Operating and Maintenance Costs	**Low**	High	Medium	Low	High	Low
Effect of Additional Dispersed Liquid on Operating Costs	**Low**	High	Low	Low	High	Low
Effect of Surface Active Chemical on Efficiency	**None**	None	Reduced Efficiency	Reduced Efficiency	Reduced Efficiency	Reduced Efficiency
Effect of Additional Dispersed Liquid on Efficiency	**Low**	Medium	Low	High	Medium	Medium
Sensitivity to Temperature Changes	**Low**	Medium	Medium	Low	High	Low
Relative Maintenance	**Low**	High	Medium	Low	High	Low

About Pall Corporation



> Pall is the largest and most diverse filtration, separations, and purifications company in the world.

For more than 60 years, Pall Corporation has been solving complex contamination problems for diverse customers around the world. With revenues of more than $2.7 billion, Pall is the largest and most diverse filtration, separations, and purifications company in the world.

Our products and services allow customers to meet regulatory requirements and increase output while reducing total cost of ownership.

Our enabling technologies help make customers' products better, safer and even possible.

Pall continues to develop new products and systems to further its cutting-edge phase separation technology. Pall's core competency in coalescing technology has helped reduce operating and maintenance costs at refineries.

We invite you to learn more about our technology, products, and services. For more information contact your Pall representative or visit us on the web at: www.pall.com.

Environmental protection

Pall is dedicated to helping customers minimize their carbon footprint, maximize recycling and waste reduction, and ensure the most efficient utilization of natural resources and raw materials. We are applying the same know-how and dedication to our own operations.

We team with customers in ways specific to their industries, providing them with technologically advanced products and engineered process solutions that improve and strengthen their businesses while reducing their environmental impacts.



Customers worldwide look to us to help them purify and conserve water, consume less energy, and minimize emissions and waste. Pall is committed to ENABLING A GREENER FUTURESM. To find out more about our green initiatives, visit us on the web at www.pall.com/green.



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