




Separations Technology in Petroleum Refining

*Understanding
Root Causes...
Finding
Solutions*

PALL



**Searching out root causes...
then applying separations
technology.**

We at Pall Corporation understand that your bottom line is more important to you than our product line. That's why we don't rush to provide quick product "fixes." Instead, we address the root causes of problems faced by the petroleum refining industry. Then we put our decades of experience and thorough technological knowhow to work to design and implement long-lasting solutions.



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 unmatched service and support. We invest heavily in R&D and technical service to provide the refining industry with exceptional returns on their investment.

Pall's filtration and separations solutions have been successfully applied in refineries throughout the world, in consultation with our customers.

Our specialized total process approach:

- *Reduces Lost Production*
- *Reduces Unscheduled Downtime*
- *Lowers Maintenance Costs*
- *Lowers Energy Costs*
- *Raises Product Yield and Conversion*
- *Meets Environmental Standards*

Pall puts together high-quality filtration systems that meet the unique requirements of every refinery we serve. We design and manufacture virtually 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 product that solves the problem. We are eager to take on any challenge and are committed to keeping up with the evolving demands of the markets we serve.

Pall delivers worldwide technological consultation and support through our Scientific and Laboratory Services Department (SLS), a network of about 400 scientists and engineers experienced in investigating and solving the 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 more than 20 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 products and systems will perform exactly as specified, no matter where in the world they are installed.

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



SLS test facility.

Contents

- Pages 9-14
Separation of Solids from Liquids
- Pages 15-19
Separation of Solids from Gases
- Pages 20-21
Separation of Liquids and Solids from Gases
- Pages 22-23
Separation of Liquids from Liquids

Refinery Filtration Recommendations

The charts below and the adjacent schematic represent typical flow systems within the refinery. Systems are detailed within the drawing and include major filter locations/applications. The numbered items in each system coincide with the recommended filter/separation application tables below.

PALL PARTICULATE/BACKWASH FILTERS*		
Application	Problem	Benefits
① Amine Sweetening	Liquid hydrocarbon and particulates cause foaming and fouling problems within an amine plant.	Reduced amine losses, foaming, and flaring; improved energy consumption; reduced maintenance, labor, and disposal costs.
② Tail Gas Treating Unit	Many tail gas units contain an amine unit.**	Same as Amine Sweetening ①
③ Aromatics	Liquid hydrocarbon and particulates cause foaming and fouling problems.	Process similar to amine; reduced solvent losses and foaming; improved energy consumption; reduced maintenance, labor, and disposal costs.
④ Catalyst Protection	Solid particulates plug and deactivate catalyst bed (5-10 µm); water can deactivate some catalysts.	Improved conversion efficiency and profitability; fewer catalyst changeouts; improved conversion/yield; lower maintenance, labor, and catalyst costs.
PALL PARTICULATE FILTERS*		
⑤ Final Product Filtration	Refinery final products contain particulates and water.	Improved product quality; fewer reprocessing and contamination costs; lower maintenance and disposal costs.
PALL BACKWASH FILTERS*		
⑥ Fluid Catalytic Cracking Unit Slurry Oil	Catalyst fines reduce value of slurry oil.	Improved product quality and revenue; less downstream equipment maintenance.

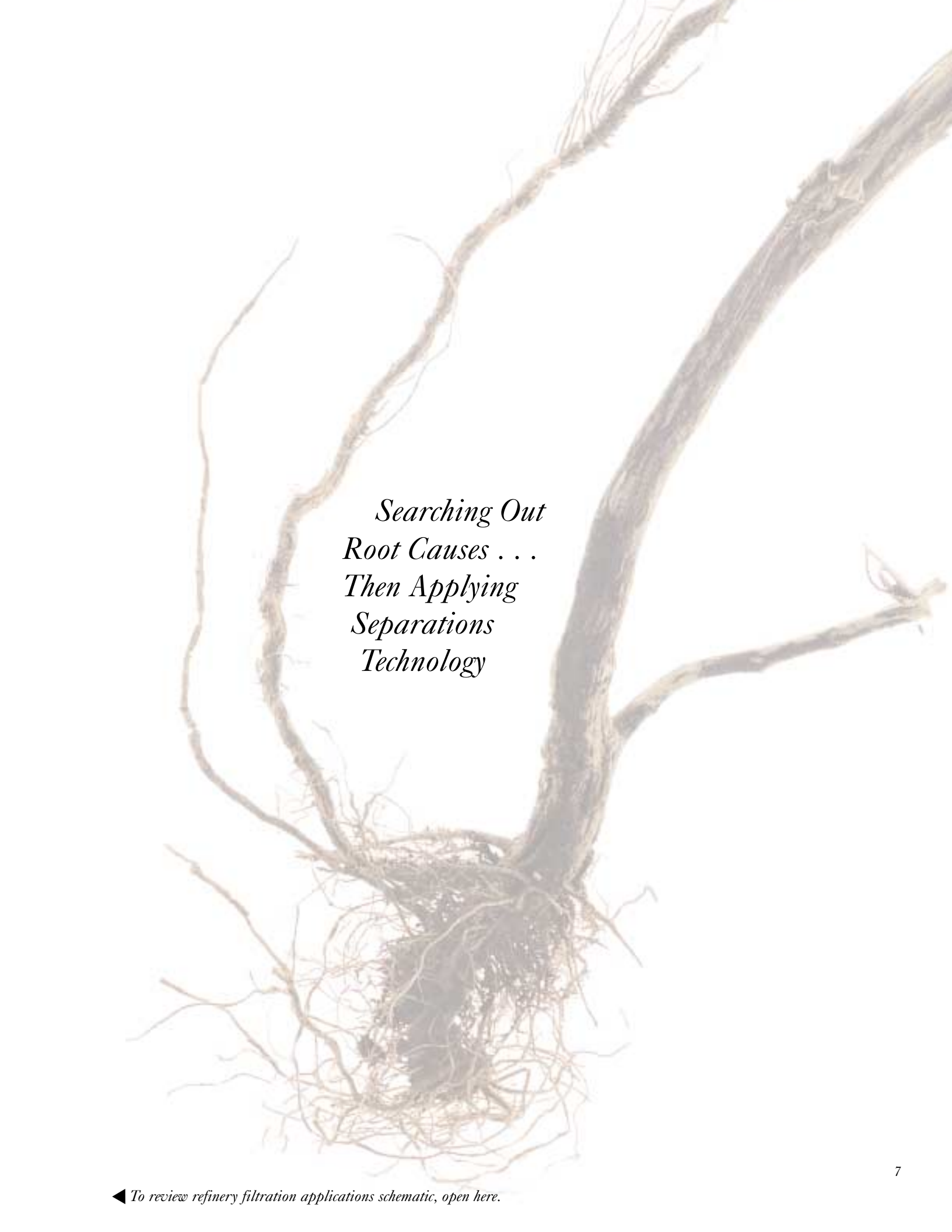
*In applications where different options are listed, Pall Corporation will assist project engineers in determining the optimum filtration option.

**Note: Many TGTU's contain another amine plant to remove residual H₂S.

PALL LIQUID/GAS COALESCERS		
Application	Problem	Benefits
⑦ Amine and Sulfur Recovery Unit	Carried-over amine contaminates catalyst at the sulfur recovery unit. Carried-over hydrocarbon and treating chemicals initiate foaming in amine contactor.	Fewer catalyst changeouts; improved sulfur conversion, less equipment fouling. Reduced amine losses, foaming and flaring.
⑧ Refinery Fuel Gas	Fuel gas composition changes rapidly, and contains condensable hydrocarbons; liquids and solids will foul, plug burners and combusters; low NOx burners very sensitive to plugging.	Improved reliability; lower maintenance costs; improved burning efficiency.
⑨ Hydrogen Compressor Protection	Hydrogen composition changes rapidly and contains condensable hydrocarbons; liquids and solids will foul internals of compressors; must know composition of liquids being recovered by coalescer.	Improved reliability; lower maintenance costs; improved efficiency.

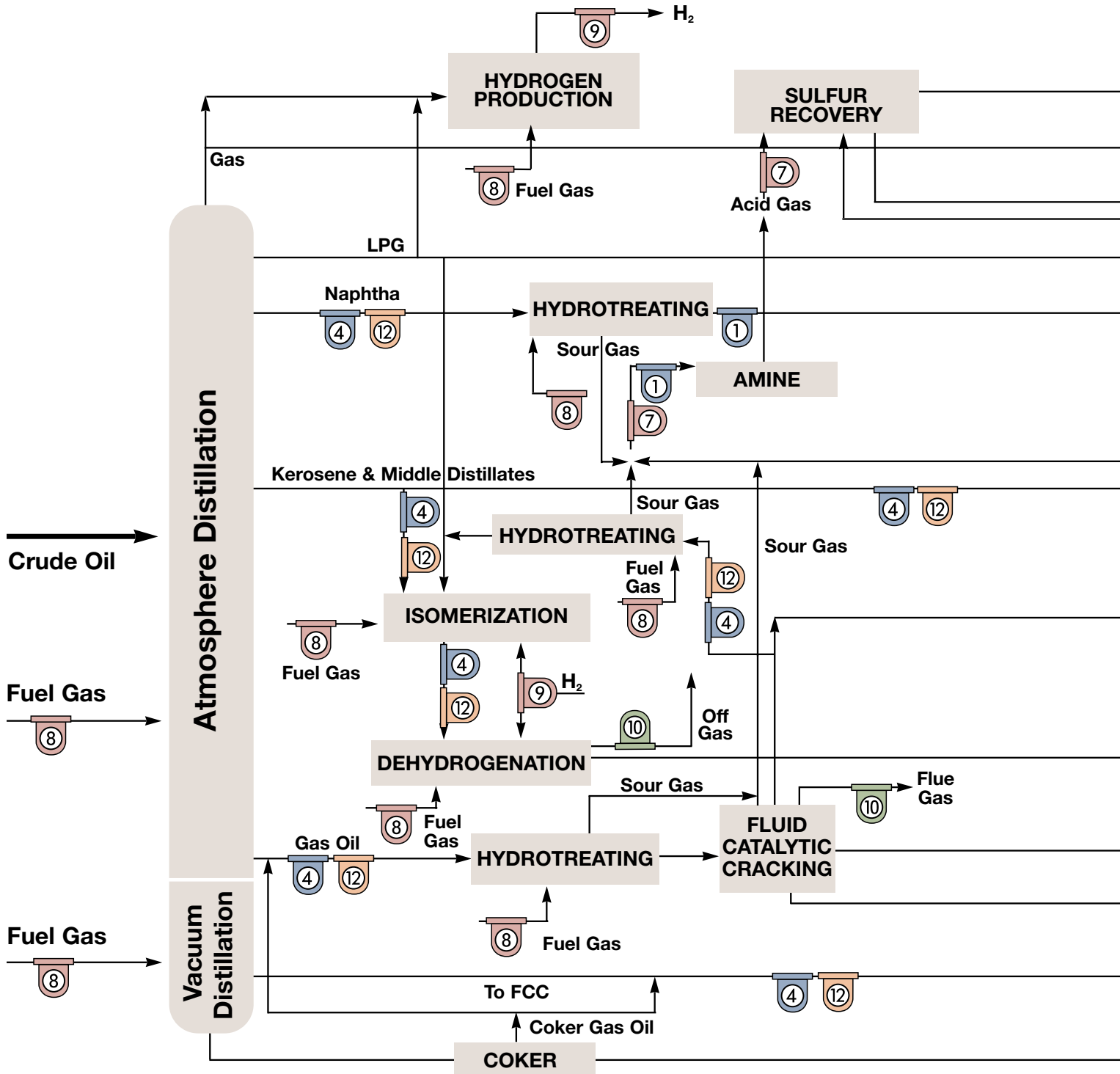
PALL BLOWBACK FILTERS*		
Application	Problem	Benefits
⑩ Catalyst Recovery from Gas Streams	Catalyst fines discharged into flue or elutriation gas causing catalyst losses, opacity problems, maintenance problems with downstream equipment. Particularly a problem where catalyst is continuously regenerated.	Fewer catalyst losses; less maintenance on downstream equipment; compliance with environmental standards.

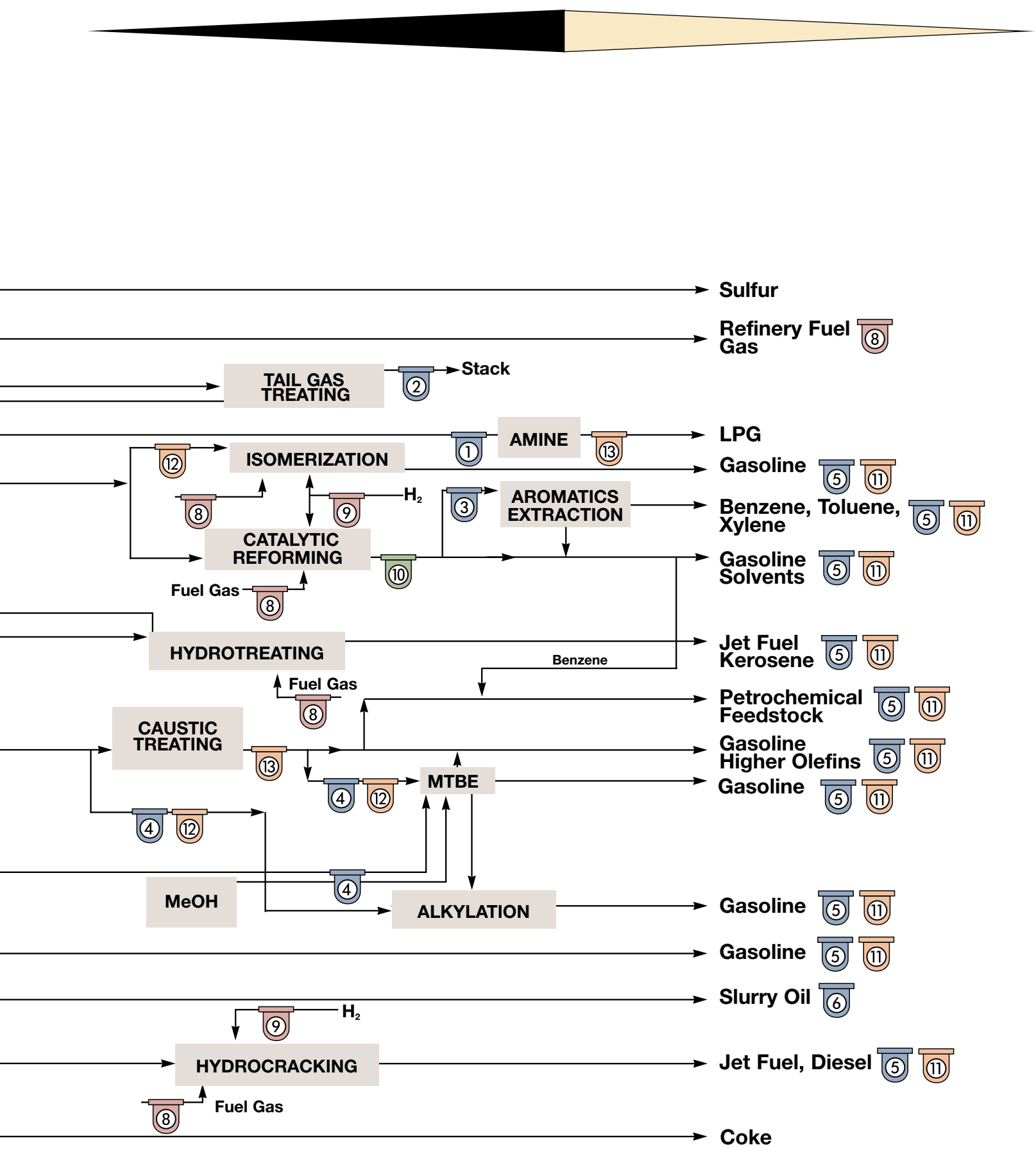
PALL LIQUID/LIQUID COALESCERS		
Application	Problem	Benefits
⑪ Final Product Filtration	Refinery final products contain particles and water.	Improved product quality; fewer reprocessing and contamination costs; lower maintenance and disposal costs.
⑫ Catalyst Protection	Solid particulates plug and deactivate catalyst bed (5-10 µm); water can deactivate some catalysts.	Improved conversion efficiency and profitability; fewer catalyst changeouts; lower maintenance, labor, and catalyst costs.
⑬ Treating	Caustic or amine carries over into product stream causing off-specification product; carried-over caustic can form a precipitate downstream resulting in equipment fouling.	Improved profitability; lower reprocessing costs; reduced maintenance and labor costs.



*Searching Out
Root Causes . . .
Then Applying
Separations
Technology*

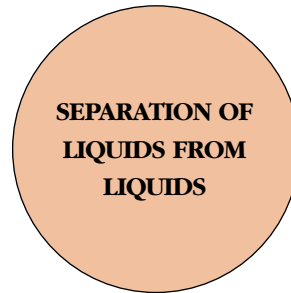
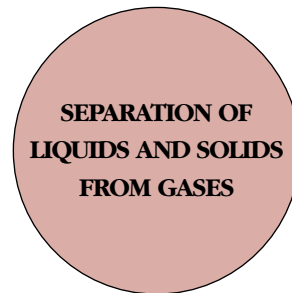
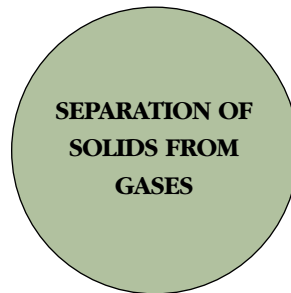
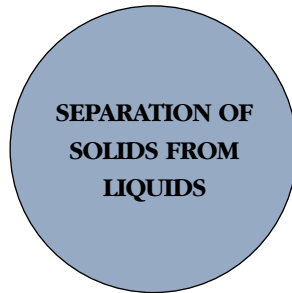
Refinery Filtration Applications





Pall Products —The Refiner's Optimum Choice

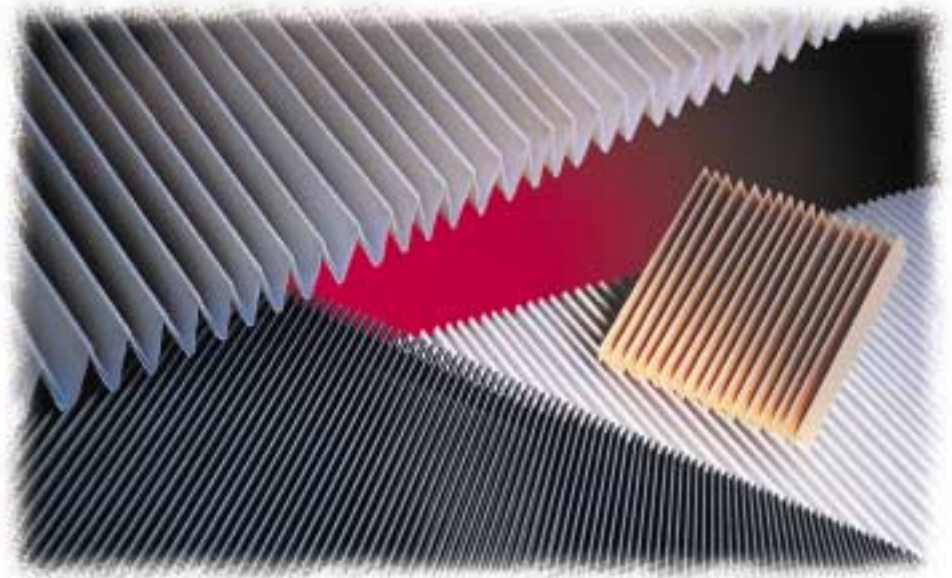
With a broad line of filtration and separation products, Pall can help refineries improve fluid quality and increase profitability by optimizing the performance of processing equipment. Many of Pall's products were developed specifically for this industry, in collaboration with our customers. Our close relationship with refiners and process licensors has helped Pall to understand their current and future needs. Our awareness of and dedication to this market have fueled our product development programs and sharpened our technical and scientific skills. In turn, Pall is able to offer expertise and a flow of new products that help maximize the efficiencies and economics of a refiner. Pall's expertise and products are categorized by the following important operations:



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

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 devices. This means Pall can supply the highest quality medium for refinery applications — without compromise.

The technology we offer for these refinery operations is identified in the four sections of this reference guide. Refer to the appropriate section for details concerning your application.



Pall filter media.

● SEPARATION OF SOLIDS FROM LIQUIDS

A variety of filtration methods can be selected for specific solid/liquid separations applications in refineries, due to the differing concentration of solids in liquid streams. For high solids loading, a backwash system may be the optimum filtration solution, while disposable filter media would be used for fairly low solids-loading applications. In some cases, removal of solids may require a combination of backwash followed by a disposable filter for polishing. Whichever filtration product or combination provides the best overall performance and economy, Pall has the capability of providing you with the solution.

Pall originally developed backwash technology in the 1960's in response to the needs of hydrogenated chemical producers. This technology started to gain acceptance in refineries in the late 1980's when refiners needed to upgrade the value of slurry oil in Fluid Catalytic Cracking units by removing catalyst fines. This continually evolving backwash technology is now used in other refining processes for the purpose of extending the life of catalyst and improving conversion in hydrotreaters and hydrocrackers. Pall Backwash Systems offer significant benefits over conventional wedgewire systems that are used to protect catalyst beds.

Pall Products

Pall Backwash Filter Media Selection

- *PSS Sintered Powder Medium*
- *Pall PMF Metal Fiber Filters*
- *Rigimesh Sintered Woven Wire Medium*
- *Pall ProSep Backwashable Filters*
- *Pall Septra Backwashable Filters*

Pall Disposable Filter Selection

- *Pall Profile II Depth Filters*
- *Pall Ultradeep Profile Depth Filters*
- *Pall Pleated Filters with Epocel Medium*
- *Ultipor GF Plus Medium*
- *HDC II Medium*
- *Pall Profile Bag Filters*



Pall Backwash Systems have extremely low operating and maintenance costs as compared with other technologies such as electrostatic separators and hydrocyclones.

Pall Backwash Systems

A backwash system is designed to remove and/or collect suspended solids from a liquid process stream while periodically regenerating itself. A porous filter medium with suitable pore size will efficiently collect solids on its surface, where they form a permeable cake. During backwash, a reverse flow will be initiated at a predetermined filter pressure drop and/or time interval, discharging the collected solids to recovery. The filter will then be returned to full forward flow. Its pressure drop just after backwash will remain essentially constant through backwash cycles.

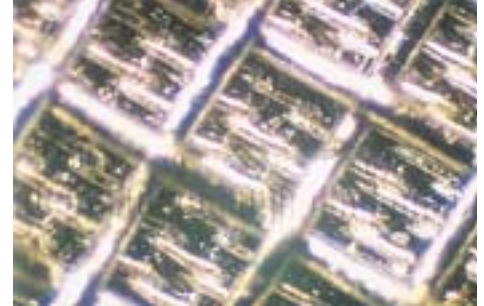
While vessel design, tubesheet assembly, piping, instrumentation, and valve selection all play an important role in their smooth functioning, backwash capability is the central feature of Pall Backwash Systems. With a variety of porous filter media, both metallic and nonmetallic, and backwash techniques, Pall's Backwash Systems are designed and optimized for specific refinery applications.

For example, many hydrotreaters use backwash filters to remove solids from the feed and protect the catalyst bed. In the past, wedgewire media were used in these systems. These media only provide about three to five percent void volume in this application. Replacing the wedgewire elements in the filter vessel with Pall Rigimesh elements provides approximately seven times higher void volume and twice the filter area. An upgrade should be based on a need for finer filtration and higher throughputs prior to backwash cycles.

Retrofits are possible and new Pall systems are being employed. The Pall Backwash System provides substantial benefits, including:

- *Improved Effluent Quality*
- *Higher Throughputs*
- *Lower ΔP*
- *Fewer Cleanings*
- *Lower Utility Costs*
- *Lower Product Recycle (reduced by as much as five-fold)*
- *Payback in Less Than 1 Year*
- *Extremely Low Cost of Operation vs. Wedgewire Systems*

Pall Rigimesh Medium versus Wedgewire



Pall Rigimesh medium—approximate void volume = 30%.



Typical wedgewire element—approximate void volume = 4%.

Backwash Systems Comparison

	Pall Backwash System	Electrostatic Separator	Wedgewire	Hydrocyclones	Sand Beds
Efficiency	High	Medium and Variable	Low	Medium	Low
Solids-Loading Capability	High	Medium	Low	High	High
Operating and Maintenance Cost	Very Low	High	Very High	Low	Low
Backwash Fluid Requirement vs. Throughput	<2%	>10%	2-20%	6%	1-2%
Sensitivity to Flow Rate Change	None	Very High	None	None	None
Temperature Range	High	Low	High	Medium	High
Reliability and Safety of Operations	High	Medium	Low	Medium	Medium



Refineries receive high return on investment after installing Pall backwash filters to protect catalyst beds and to remove catalyst fines from FCC slurry oil.

Gas-Assist Backwash Method

The gas-assist method is used when process flow rates are high, or, continuous, uninterrupted flow is required. For backwash, one vessel is isolated and the downstream side of the vessel is pressurized with a controlled quantity of filtered air or other suitable gas. The vessel drain port is rapidly opened, resulting in a hydraulic pulse that “bumps” the collected solids from the filter surface. Forward flow is restored to this vessel, and the remaining filter vessels are backwashed sequentially.

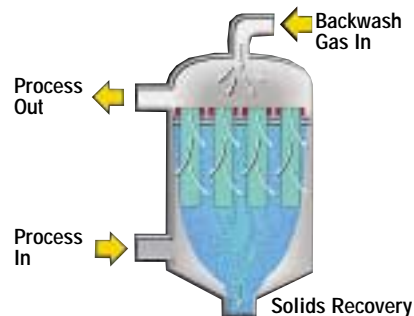
During gas-assist backwash, the expanding gas bubble forces the liquid through the elements in the reverse direction (inside-out) at a velocity as high as seven times the normal forward flow velocity. This effectively dislodges the accumulated cake from the elements, while significantly reducing the volume of liquid required. Thus, the concentration of the solids discharge is high.

Combining the gas-assist backwash with the high dirt-holding capacity of Pall’s backwash media results in long cycle times between backwashing.

Benefits of Pall Backwash Systems and Gas-Assist Backwash

- *Longer Catalyst Life*
- *Reduced Incidence of “Off-Spec” Product*
- *Low Reprocessing and/or Disposal Costs Due to Low Volume of Backwash Fluid*
- *Low Maintenance Cost for Valves and Control Equipment*
- *Infrequent “Out-of-Vessel” Element Cleaning*

Pall Backwash System



- *One or More Vessels*
- *Isolate One Vessel for Backwash*
- *A Compressed Volume of Gas Provides a High-Velocity Reverse Flow of Liquid Remaining in Vessel*

Pall Metallic Backwash Filter Selection



Porous Metal PSS Filters

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

These elements are seamless in construction with very high void volume (up to 60% in some grades). This provides very high dirt-holding capacity and low pressure loss, especially in very fine grades, which permit design at high flux to help reduce capital costs.

In addition to the standard product made from 316L stainless steel, we supply PSS medium in Inconel, nickel, nickel molybdenum, and aluminide alloys.



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 with exceptionally high dirt-holding capacity while one or more inner layers provide absolute-rated filtration.



Rigimesh Stainless Steel Woven Wire Mesh Filters

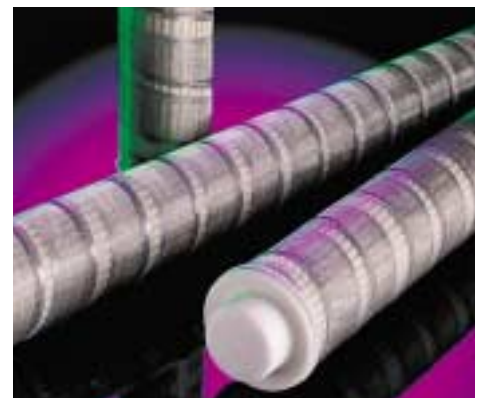
Pall’s patented process permits the use of finer-diameter wires in the manufacture of the Rigimesh stainless steel medium. This results in low pressure drop, more pores per unit area, and better dirt-holding capacity than that of any other woven metal filter. The medium is sintered for superior tensile, yield, shear, and fatigue strength. Rigimesh maintains a uniform pore size and exhibits no media migration, even under high temperature and pressure conditions.

Pall Nonmetallic Backwash Filter Selection



ProSep Filters

Pall ProSep filters are manufactured of polyolefin or polyaramid fiber, both of which provide outstanding temperature and chemical compatibility. These filters have an outer (upstream) section in which fiber diameter and pore size decrease gradually to the element’s innermost layer where the pore diameter is constant. Designed for use with or without a precoat, beta-rated ProSep filters are the appropriate choice in applications in which the process fluids have a high solids content.



Septra Filters

Septra filters incorporate a pleated, high-area absolute-rated polymeric medium in a rugged element construction designed for operation (without use of a precoat) in automated, clean-in-place fluid/solid separation systems. The high-area filter medium is a nonwoven construction that is available with polyolefin, polyaramid, or fiberglass fibers to suit operation up to 500°F (260°C).

Pall Disposable Filters

When the solids concentration is relatively low (< 5 to 10 ppm), Pall disposable filters will efficiently and economically remove solids from liquid streams. Pall filters are used to remove solids from finished refinery products and from processing fluids such as amines, glycol, and sulfolane. Pall filters are characterized by high dirt-holding capacity, and lot-to-lot uniformity. They provide long service life and improved protection for equipment and personnel. Pall filter elements are designed to prevent both unloading of trapped particles and media migration. They are self-aligning in Pall filter vessels, with positive sealing to eliminate fluid bypass.

Pall disposable filters are designed and manufactured for long, effective, trouble-free service life. Their advantages include:

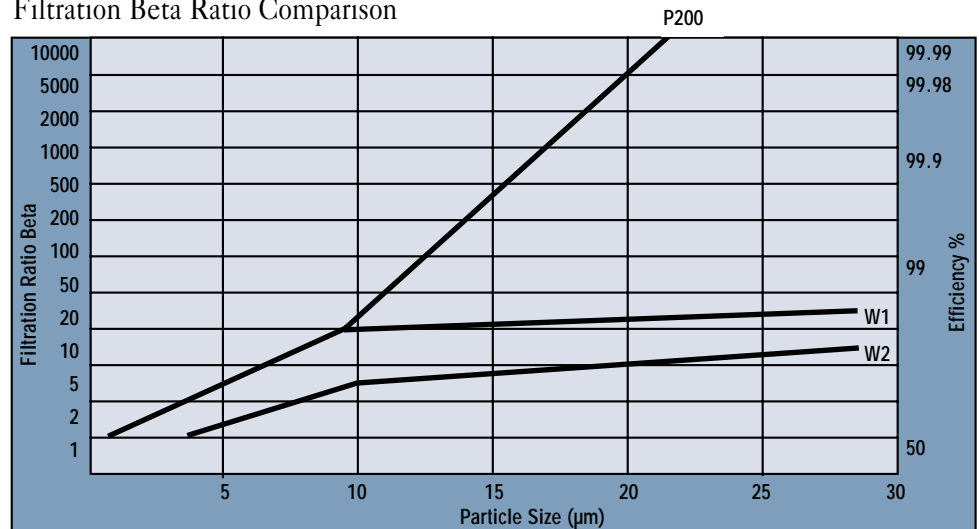
- *Pore Size Uniformity for Full Utilization of the Filter Surface*
- *Strength and Durability to Withstand the Changing Process Operations*
- *Chemical and Thermal Compatibility with Process Conditions to Ensure Long Life*
- *Absolute Rating* for Reliable, Replicable Performance, Backed by Documented Performance Data*

* An "absolute rating" is defined as $B_{20}=5000$ as measured utilizing widely accepted modified OSU F-2 test.

Comparison of Performance of Profile II Filters and Competitive Depth Filters

Particle Size (µm)	Filter Brand		
	Profile II (P200) 20 µm Absolute $B_{20} = 5000$	W1 Wound Filter 1 µm Nominal $B_1 = 1$	W2 Spun Depth Filter 1 µm Nominal $B_1 = 1$
	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



Filtration beta ratio of Profile II grade 200 and two competitive polypropylene depth filters rated at 1 µm nominal.

Pall Disposable Filter Selection



Profile II Filters

Profile II is a polymeric depth-type medium produced by a patented process that allows an upstream continuously graded section and a downstream absolute-rated section in a single element.



Ultipleat Profile Filters

The unique crescent-shaped construction of the Ultipleat Profile filter element provides longer life than many pleated polypropylene media. Optimized for the removal of gels and other viscous fluids, the Ultipleat Profile filter provides excellent chemical compatibility with low extractables. Ultipleat Profile filter elements are the appropriate choice for a wide range of applications in the refining industry.



Epocel Filters

Epocel cartridges 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 cartridges 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

The Ultipor GF Plus medium consists of resin-bonded glass fibers supported by upstream and downstream polymeric substrates. This unique construction provides a strongly bonded, migration-free, high-dirt-capacity medium.



HDC II Filters

The HDC II medium consists of multiple layers of continuous fiber, non-woven polypropylene pleated together, with no binders or extraneous material. HDC II cartridges have an extremely high dirt capacity, due to their tapered-pore construction, and a wide range of chemical compatibility.



Profile Bag Filters

High-efficiency, beta-rated Profile bag filters are suitable for a wide variety of applications. They contain an outer (downstream) section that has a constant pore diameter to provide consistent, beta-rated filtration. The inner (upstream) section continuously increases in pore diameter to provide effective prefiltration. The tapered-pore structure and depth of the medium combine to provide long service life.

● SEPARATION OF SOLIDS FROM GASES

Dealing with aggressive environments, extreme temperatures, and high contaminant concentrations, Pall has continually developed state-of-the-art technology for solid/gas separation. To efficiently separate solid particulates from gas streams, Pall has worked with both refiners and process licensors to develop blowback systems. 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 Blowback Systems contain either porous metal or ceramic filters. The superior capabilities of Pall Blowback Systems, as opposed to other types of equipment, are shown in chart at right.

Pall Products

Pall Blowback Filter Media Selection

- *Pall PMF Metal Fiber Filters*
- *PSS Sintered Powder Filters*
- *Rigimesh Sintered Woven Wire Medium*
- *Vitrosep Blowback Filters*
- *Vitropore Ceramic Filter Candles*

Pall Gas Particle Disposable Filter Selection

- *Pall Pleated Filters with Ultipor GF Plus Medium*
- *HDC II Medium*
- *Epocel Medium*
- *Pall Utiplateat Profile Filters*
- *Pall Profile II Depth Filter*



Pall blowback filter system in operation.

Blowback Systems Comparison

	Blowback Pall 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	1650°F	>2000°F	450°F	450°F	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 Blowback Filter Selection



Porous Metal PSS Filters

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

These elements are seamless in construction with very high void volume (up to 60% in some grades). This provides very high dirt-holding capacity and low pressure loss, especially in very fine grades, which permit design at high flux to help reduce capital costs.

In addition to the standard product made from 316L stainless steel, we supply PSS medium in Inconel, nickel, nickel molybdenum, and aluminide alloys.



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 with exceptionally high dirt-holding capacity while one or more inner layers provide absolute-rated filtration.



Rigimesh Stainless Steel Woven Wire Mesh Filters

Pall’s patented process permits the use of finer-diameter wires in the manufacture of the Rigimesh stainless steel medium. This results in low pressure drop, more pores per unit area, and better dirt-holding capacity than that of any other woven metal filter. The medium is sintered for superior tensile, yield, shear, and fatigue strength. Rigimesh maintains a uniform pore size and exhibits no media migration, even under high temperature and pressure conditions.



Vitrosep Blowback Filters

The rugged construction of the Vitrosep clean-in-place blowback filter allows jet pulse cleaning and operation at high flux. This reduces the system footprint and lowers installed cost of the equipment. Equipped with a one micron rated Teflon coated fiberglass medium, Vitrosep is constructed of a stainless steel core, outer mesh wrap, and end caps.



Vitropore Ceramic Filter Candles

This rigid, highly efficient silicon carbide medium possesses high temperature and excellent corrosion resistance for gas clarification and solids recovery.

The ability of every Pall Vitropore candle to withstand corrosion and fracture at high temperatures (to 1000°C) proves it has the necessary characteristics to clean up hot gases. At temperatures above 650°C, Vitropore candles are more resistant to corrosion than most metal filters.

Pall Gas Particle Disposable Filter Selection



HDC II Filters

The HDC II medium consists of multiple layers of continuous fiber, non-woven polypropylene pleated together, with no binders or extraneous material. HDC II cartridges have an extremely high dirt capacity, due to their tapered-pore construction, and a wide range of chemical compatibility.



Epocel Filters

Epocel cartridges 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 cartridges 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

The Ultipor GF Plus medium consists of resin-bonded glass fibers supported by upstream and downstream polymeric substrates. This unique construction provides a strongly bonded, migration-free, high-dirt-capacity medium.



Ultipleat Profile Filters

The unique crescent-shaped construction of the Ultipleat Profile filter element provides longer life than many pleated polypropylene media. Ultipleat Profile filter elements are the appropriate choice for a wide range of applications in the refining industry.



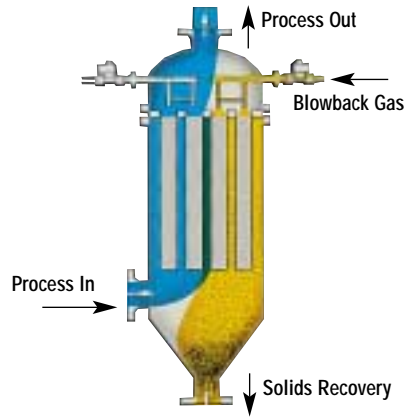
Profile II Filters

Profile II is a polymeric depth-type medium produced by a patented process that allows an upstream continuously graded section and a downstream absolute-rated section in a single element.

Jet Pulse Blowback Method

The jet pulse blowback method is cost effective because it 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 high-pressure pulse of gas into the throat of each element. The pulses last between 0.1 and 1.0 second, 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 Blowback System



- *One or More Vessels*
- *Full Forward Flow Maintained*
- *Groups of Elements Blowback Sequentially*
- *Forward Flow Overcome by High-Pressure Pulse in Reverse Flow. Short Duration (0.1 to 1.0 Seconds)*



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

There are numerous applications for Pall Blowback Systems, including:

Catalytic Reforming

Pall Blowback Systems are used in catalytic reforming units where catalyst is continuously regenerated to protect against erosive wear and fouling of the recycle compressor. These systems filter the elutriation gas that is recycled back to the regenerator. For example, Pall PSS porous stainless steel elements (rated one micron in gaseous service) with jet pulse (blowback) *in-situ* cleaning are used. Extensively tested, Pall PSS filters are now installed at refineries throughout the world. Typically more than 99.99% of the solids in the recycled gas are removed by the type 316L stainless steel medium.

Catalytic Cracking

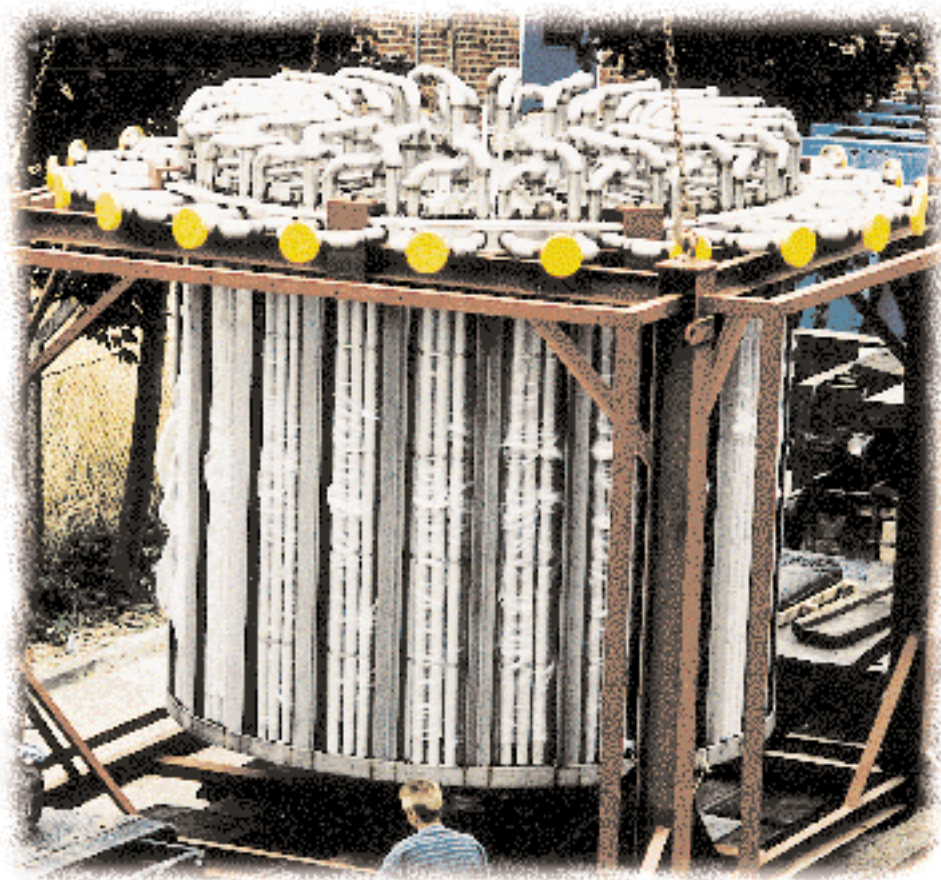
Pall Blowback Systems used to remove catalyst fines from FCC flue gas allow the refiner to:

- Meet emission guidelines, and
- Fully protect downstream process equipment.

In the U.S., the permissible particulate emission for a fluidized-bed catalytic cracker (FCC) was set at 0.1 gm/nm^3 in 1990. However, emission standards in states such as California are expected to be reduced to 0.006 gm/nm^3 by 1995, with similar emission targets proposed in Europe and Japan. Depending on the economics at a specific refinery, there are several blowback options:

A) Where turbo expanders are in service, a hot gas filter is necessary 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 combustors with an even more corrosive and hotter environment than FCC, Pall Vitropore ceramic candle filters have proven to be efficient and reliable. As is not the case with cyclones, the removal efficiency remains constant during variations in gas flow rate.



Fluid bed catalyst recovery filter bundle.

B) If turbo expanders are not used, Pall Vitrosep clean-in-place blowback filters are recommended to meet emission guidelines consistently.

Unlike that of electrostatic precipitators, which are often used for this service, the removal efficiency of Vitrosep elements remains constant during flow surges (upset conditions) and is not affected by changes in the electrostatic charge of the particulate matter.

C) If third- and fourth-stage cyclones are in place, replacing the fourth stage with Vitropore filters will improve solids capture, which may, of itself, be sufficient to meet emission guidelines at minimum capital investment.

Dehydrogenation Processes

Pall PSS seamless porous metal elements process the catalyst regenerator off-gas at dehydrogenation plants operating fluid bed reactors. The Pall 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 LG coalescers have been used in refineries and gas processing plants for more than twenty years. The Pall LG coalescer provides maximum liquid and solid removal at low saturated pressure drop to reduce maintenance and operating costs associated with contaminated gas. The element's high effective filtration area and resin-bonded pleated cartridge construction is surrounded by nonwoven polymeric support and drainage layers. The coalescer is rated 0.3 μm (99.97% 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 with minimal labor requirements, as well as greatly improved equipment reliability.

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

Pall Product

Pall Liquid/Gas (LG) Coalescer



Pall LG coalescers remove liquids and solids from hydrogen and fuel gas, protecting turbo machinery and combustion equipment.

Liquid/Gas Coalescer Comparison

	Pall High Efficiency LG Gas 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	Insensitive	Very Sensitive	Medium	Medium	Medium
Sensitivity to Increased Flow Rate	Some to None	Very Sensitive	Medium	Medium	Medium
Sensitivity to "Turn-Down"	Insensitive	Very Sensitive	Medium	Medium	Medium

There are numerous applications, including:

Hydrogen Compressor Protection

Pall LG coalescers are installed in front of hydrogen compressors to protect blading or cylinders and prevent costly unscheduled downtime. Refiners have been able to extend regular maintenance schedules by installing LG coalescers upstream of 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 in refineries. By removing such contaminants, Pall LG coalescers significantly reduce the maintenance associated with plugged burner tips in process furnaces. Low NO_x 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. The lube oil often is discharged into the process gas in aerosol form. An LG coalescer placed at the discharge of a compressor will recover the lube oil and prevent contamination of downstream catalyst, desiccant, and activated carbon beds.

Gas Treating Processes/ Sulfur Recovery

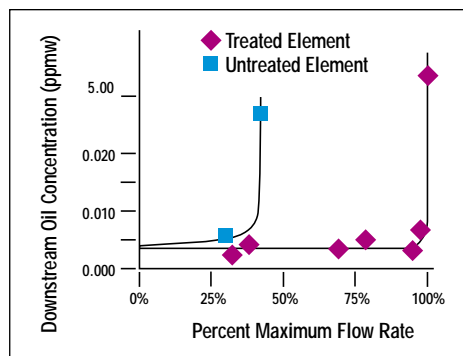
In amine treating units, foaming can be initiated by liquid hydrocarbon contaminants in the feed gas. Installation of an LG coalescer upstream of the amine contactor can reduce the costs associated with foaming such as reduced processing capacity and increased amine losses. LG coalescers can also recover any amine that is carried over into the acid gas or the treated gas.



Liquid/Gas (LG) Coalescer

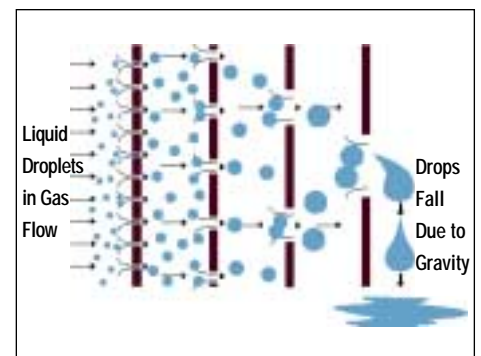
Pall LG coalescers perform with maximum removal efficiency and economy that reduces equipment downtime and labor and maintenance costs. The unique filter medium provides for single-stage coalescing; separating liquid aerosols smaller than 0.1 micron in size. Pall's patented coalescer treatment improves the drainage of liquids through the coalescer, allowing for 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 us to recurring problems with hazy fuel and caustic carryover, Pall worked with them to quickly develop the AquaSep and PhaseSep liquid/liquid coalescers. We consulted with our customers during every step of product development and design to ensure that the AquaSep and PhaseSep coalescers met their every need.

Today, AquaSep and PhaseSep coalescers are installed in refineries throughout the world for use in several applications, including:

- *Removal of Water from Gasoline, Diesel, Kerosene, and Jet Fuel*
- *Protection of Catalysts from Water Contamination*
- *Removal of Carried-Over Caustic from Caustic Treating Processes*
- *Removal of Carried-Over Amine from LPG*

The Pall AquaSep and PhaseSep coalescers are multiple-stage systems. They first remove particulate matter, then coalesce and separate the water or liquid contaminant from a hydrocarbon stream. An AquaSep or PhaseSep coalescer will remove entrained water to a level at or below 15 ppmw with influent conditions of:

- Inlet water concentration as high as 10% water by weight
- Interfacial tensions 2 dyne/cm and above

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 liquid/liquid coalescers do not disarm in the presence of surface active agents in the fuel.

Pall Products

***Pall AquaSep
Liquid/Liquid Coalescer***

***Pall PhaseSep
Liquid/Liquid Coalescer***



Compared with other methods, like tank settling, electrostatic precipitation, salt driers, sand filters, and mesh pads, Pall's AquaSep and PhaseSep coalescers are the most cost-effective technique for liquid/liquid separation.

Unique Stack Design

Pall's AquaSep and PhaseSep coalescer element is stacked on top of a separator element. This 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. These conventional two-stage systems require several coalescer elements for each separator. Pall's stack design results in 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 (i.e., > 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

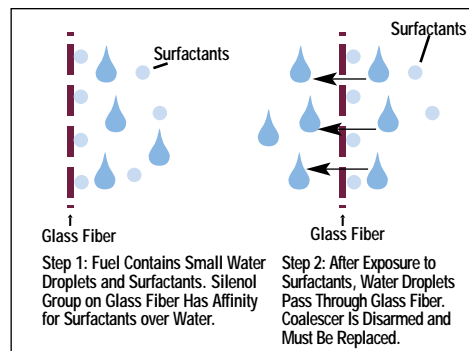
Surfactants in fuels have a tendency to form fuel/water hazes and can degrade the performance or disarm conventional glass fiber coalescers. Pall's liquid/liquid coalescers do not contain glass fiber, but are constructed of polymeric material using a unique patented process. This results in long, reliable,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



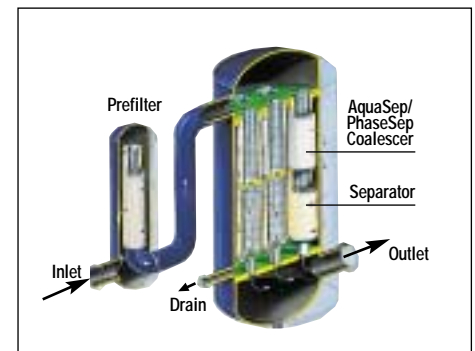
AquaSep and PhaseSep Liquid/Liquid Coalescers

Both of these coalescers were developed to efficiently separate very stable liquid/liquid dispersions to 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 changeouts, which reduces maintenance and disposal costs.

Mechanism for Disarming



AquaSep and PhaseSep Liquid/Liquid Coalescer



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

Liquid/Liquid Coalescer Comparison

	Pall AquaSep/PhaseSep System	Salt and Desiccant Tower	Conventional Coalescers	Pack Bed Tower	Electrostatic Precipitator	Tank Settling
Lowest Interfacial Tension Efficiency Separated	AquaSep: 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 Cost	Low	High	Low	Low	High	Low
Effect of Surface Active Chemical on Efficiency	None	None	Reduces Efficiency	Reduces Efficiency	Reduces Efficiency	Reduces 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

Pall's Global Network of Support and Service

Pall is a global enterprise in every sense of the word, with 60% of our sales emanating from outside the United States. Our solids separation systems and fluid clarifiers are produced at our state-of-the-art plants in Cortland, New York; Fajardo, Puerto Rico; and Portsmouth, England. These facilities have been certified to ISO 9001 standards.

Our successful, expanding organization develops a steady stream of innovative products designed to meet the high manufacturing standards of refiners. We back these products with uncompromising support and service in the field. Moreover, our distribution network serves as a corporate asset unique to our company. Pall has successfully developed these strategies to best serve our customers in all the markets and locations in which we operate. Serving our global customers with highly technical and specialized product lines requires our commitment to:

- Visit customers to assist in the selection of the right filtration solution — our highly trained technical sales engineers and actively involved scientists from our Scientific and Laboratory Services Group provide invaluable information.
- Get the right products to the customer on time.
- Follow with technical service and support to ensure a successful installation and satisfied customers.

With our success in the refining industry stemming from our ever-expanding manufacturing and technical capabilities, we are confident that Pall will meet your specific requirements for a

wide variety of refinery applications. Pall offers its dedication and commitment to provide the best economical and reliable solutions to all of our customers through "Absolute Performance."



★ Pall Owned Sales & Distribution Centers ■ Manufacturing Facilities

<i>Austria</i>	<i>Hong Kong</i>	<i>Singapore</i>	<i>Japan</i>
<i>Australia</i>	<i>Italy</i>	<i>Spain</i>	<i>Puerto Rico</i>
<i>Canada</i>	<i>Japan</i>	<i>Switzerland</i>	<i>United Kingdom</i>
<i>China</i>	<i>Korea</i>	<i>United Kingdom</i>	<i>United States</i>
<i>France</i>	<i>Poland</i>	<i>United States</i>	
<i>Germany</i>	<i>Russia</i>		

▲ Research & Development

<i>Japan</i>
<i>United Kingdom</i>
<i>United States</i>

● Scientific & Laboratory Services Locations

<i>Austria</i>	<i>Indonesia</i>	<i>Singapore</i>
<i>Australia</i>	<i>Italy</i>	<i>Spain</i>
<i>Brazil</i>	<i>Japan</i>	<i>Switzerland</i>
<i>Canada</i>	<i>Korea</i>	<i>Taiwan, R.O.C.</i>
<i>China</i>	<i>Mexico</i>	<i>Thailand</i>
<i>France</i>	<i>Poland</i>	<i>United Kingdom</i>
<i>Germany</i>	<i>Puerto Rico</i>	<i>United States</i>
<i>India</i>	<i>Russia</i>	





Pall Offices Throughout The World

Australia

Pall Australia

106 Talinga Road
Cheltenham, Melbourne,
Victoria 3192
Tel: 011-61-39-584-8100
Fax: 011-61-39-584-6647

Austria

Pall Austria

Filter Ges.m.b.H.

Wichtelgasse 57-59
Vienna A-1170
Tel: 011-43-149-1920
Fax: 011-43-149-192-33

Canada

Pall Canada, Ltd.

7205 Mill Creek Drive
Mississauga, Ontario L5N 3R3
Tel: 905-542-0330
Fax: 905-542-0331

China

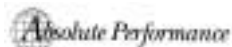
Pall Filter (Beijing) Co. Ltd.


No. 12 Dongdaqiao Road
Chaoyangmeng wai
Beijing P.R. China 100020
Tel: 011-86-10-508-0899
Fax: 011-86-10-508-1266

France

Pall Corporation

Bureau Européan
14 rue des Gaudines BP 229
78108 Saint Germain-en-
Laye, Cedex
Tel: 011-33-13061-3800
Fax: 011-33-1-3451-0414



Pall, , PSS®, PMF™, Rigimesh®, Prosep™, Septra™, Profile®, Profile®II, Ultipleat™, Profile®, Epocel®, Ultipor GF Plus®, HDC®II, Vitropore™, Vitrosep™, AquaSep™ and PhaseSep™ are trademarks of Pall Corporation. ® indicates that the trademark is registered in the U.S.A.

Germany

Pall Filtrationstechnik GmbH

Philipp-Reis-Strasse 6,
D-63303 Dreieich
Tel: 011-49-6103-3070
Fax: 011-49-6103-34037

Hong Kong

Pall Asia International Ltd.

Room 2806-7, Shui On Centre
6-8 Harbour Road, Wanchai
Hong Kong
Tel: 011-852-2583-9610
Fax: 011-852-2511-5773

Italy

Pall Italia s.r.l.

Via G. Bruzessi 38/40
20146 Milano
Tel: 011-39-247-7961
Fax: 011-39-241-2985

Japan

Nihon Pall Ltd.

1-5-1 Nishi Gotanda,
Shinagawa-ku
Tokyo 141 Japan
Tel: 011-81-33495-8380
Fax: 011-81-33495-8369

Korea

Pall Korea Ltd.

PG Building 3rd & 4th Floors
1023-6 Daechi 1 Dong,
Kangnam-Gu
Seoul, Korea 135281
Tel: 011-82-2569-9161
Fax: 011-82-2569-9092

Poland

Pall Poland Ltd.

UI Kasprowicza 151 pok.315
01-949 Warszawa
Tel: 011-48-2-235-8383
Fax: 011-48-2-234-2817

Russia

Pall Moscow Office

Volokolamskoye Shosse 75
Moscow 123424
Tel: (007095) 490-6807
Fax: (007095) 490-6982

Singapore

Pall Filtration Pte, Ltd.

No. 5 Kallang Way 5
Singapore, 1334
Tel: 011-65-744-8255
Fax: 011-65-743-4938

Spain

Pall España s.a.

Edificio Mendez,
C/Isla de Corcega No. 2
Alcobendas, 28100 Madrid
Tel: 011-34-1-661-5517
Fax: 011-34-1-661-4072

Switzerland

Pall (Schweiz) AG

Hofackerstr. 73
CH-4132 Muttenz
Tel: 011-41-61-461-6210
Fax: 011-41-61-461-7533

United Kingdom

Pall Europe Limited

Europa House, Havant St.
Portsmouth, PO1 3PD
Tel: 011-441-705-303303
Fax: 011-441-705-302509

USA

Pall Corporation

2200 Northern Boulevard
East Hills, New York
11548-1289
Tel: 516-484-5400
Fax: 516-484-6164

Visit our web site at: <http://www.pall.com>

Distributed By: