Pall Corporation

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Coalescers

Bring down costs through advanced phase separation technology

*Filtration. Separation. Solution.*SM

Pall Phase Separation Technology for Control and Protection of Your Plant

Contents

Every year, refineries, gas processing plants, and petrochemical plants around the world spend millions of dollars needlessly on their operations. Maintenance cycles are shorter than they should be; operating costs are higher than necessary; and unscheduled shutdowns causing lost production are all too common.

Fortunately, solutions are readily available from one source — Pall Corporation. Pall is a leader in filtration, separation and purification. Pall's products are used throughout the world to meet the demanding needs of its customers.

Pall's SepraSol™ liquid/gas coalescers, as well as its AquaSep® Plus and PhaseSep® liquid/liquid coalescers, provide excellent coalescing efficiency, capacity, and contaminant removal to improve your process.

Pall Corporation is a unique resource for phase separations. Pall can help you achieve a higher degree of product control and equipment protection through our advanced technology and teamwork.

Three Essential Phase Separation Steps to Reduce Operating and Maintenance Costs

Our customers benefit from our experience in developing filtration and separations technology. This has reduced costs in hundreds of installations around the world. There are three essential steps to achieving cost reductions in your plant.

1 Preconditioning of the Fluid

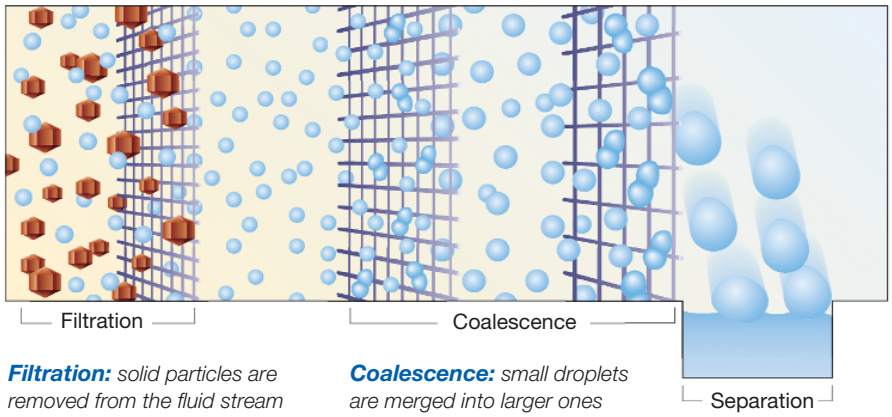
Pall recommends a prefilter to minimize solids in the coalescer influent that can plug the coalescer, reducing the overall life and efficiency. The prefilter provides peak performance of the coalescing system and a lower total cost of ownership.

2 Coalescence of the Dispersed Phase

Pall high-efficiency coalescers merge small droplets of liquid into larger ones as the fluid stream passes through several layers of filter media, each with progressively larger pores. As droplets compete for the open pores, they coalesce forming larger droplets. These larger droplets are easier to separate from the continuous phase fluid. The coalescer size and type are determined by numerous factors: physical properties of the fluid, flow rate, process conditions and chemical compatibility with process fluids and additives. Pall has the expertise and capability to determine the correct coalescer size and type for your specific process parameters.

3 Separation of the Dispersed Phase from the Continuous Phase

Once large droplets are formed, they have to be separated. In gas systems, Pall spaces the cartridges to control the exit velocity of the gas so that coalesced droplets are not entrained in this stream. In liquid/liquid systems, depending on the liquid to be separated, Pall will provide a separator cartridge which has “repelling” properties toward the coalesced liquids. Alternatively, the assembly can be designed to allow time for the coalesced liquid to settle. When Pall works with you in all three phase separation steps, the result is greater process efficiency and reduced operating and maintenance costs.



Filtration: *solid particles are removed from the fluid stream by the filter medium.*

Coalescence: *small droplets are merged into larger ones as they pass through several layers of filter media in the coalescer.*

Separation: *gravity takes effect, the large droplets are separated from the product fluid stream.*

Pall SepraSol Coalescers for Separating Liquids and Solids from Gases

Pall can eliminate a common problem — poor liquid separation. It is a problem that eats away at profit margins. Liquid aerosols, which are dispersed in gases, attack several critical areas of your process: compressors and turbo-equipment, amine-glycol contactors, burner and combustion equipment, and desiccant and adsorbent beds. Typical symptoms include:

- Compressor valves that need changing out more than once every two years
- Turbo-equipment servicing more than once a year
- Plugging of reboiler heat exchangers or trays in contactor towers
- Frequent replacement of amines and glycols
- Frequent foaming incidents
- Loss of efficiency in burner and combustion equipment
- Frequent desiccant regeneration or replacement

The Efficient Way to Remove Liquids

Liquid aerosols are formed by three mechanisms: condensation, atomization, and reentrainment from upstream separation equipment. Condensation and atomization almost always form very stable, fine aerosols usually smaller than one micron in diameter.

Such aerosols cannot be removed by “knock-out drums,” mist eliminators, vane packs, or conventional coalescers. If not removed, these aerosols can damage downstream equipment.

The solution is Pall’s proprietary SepraSol coalescers. They are rated up to 99.99% removal efficiency for solid particles 0.3 micron and larger, and reduce liquid content in gas streams down to 0.003 ppmw.

A SepraSol liquid/gas coalescer protects a natural gas turbine from damage caused by liquid aerosols.

Pall SepraSol Liquid/Gas Coalescers Outperform All Others

Pall's unique filter media and cartridge design can handle higher liquid loads than conventional coalescers, resulting in the need for fewer cartridges. The proprietary oleophobic/hydrophobic treatment of the media pack promotes rapid drainage of coalesced liquids. Effluent gas exit velocities are controlled to prevent liquid reentrainment. The result — higher flux in the smallest cost-effective package which ensures continuous and reliable performance.

Higher Flux

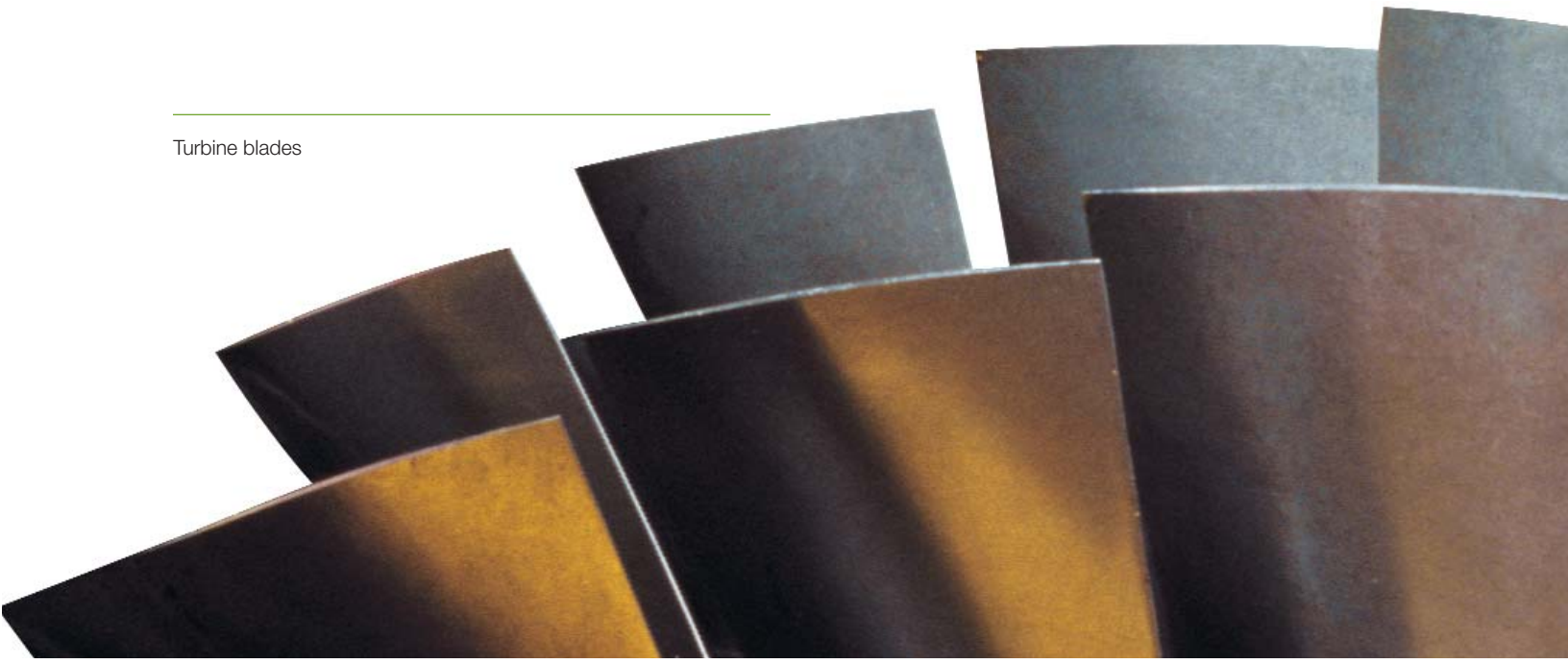
Pall's oleophobic/hydrophobic treatment of the media allows it to handle higher gas velocity and higher liquid loads without allowing coalesced liquid droplets to break up and become reentrained.

Better Drainage

This treatment also promotes rapid drainage of coalesced liquids and increases the liquid handling capacity of the media. Smaller assemblies are able to handle higher liquid volumes at a lower capital cost, recover faster from liquid slugs, and operate at a lower cost due to the lower saturated pressure drop.

Left: Deposits form on a turbine blade.
Right: A turbine blade protected by a SepraSol liquid/gas coalescer.

Left: Clean desiccant.
Right: Fouled desiccant. Change-out and regeneration cycles will be significantly extended using Pall's SepraSol liquid/gas coalescers.



Turbine blades

Comparison of Liquid/Gas Separation Equipment

The table below compares the various equipment available for removing aerosols. Pall SepraSol coalescers effectively remove aerosols smaller than one micron.

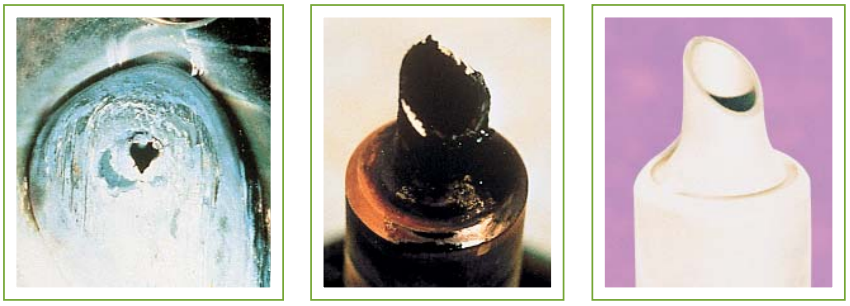
	Pall Seprasol Liquid/Gas Coalescer	Mist Eliminator	Vane Separator	Cyclonic Separator	Knock-out Drum
Smallest Liquid Droplet Efficiently Removed (Micron)	< 0.1	5	10	10	300
Relative Operating Pressure Drop	Medium	Medium	Medium	Medium	Low
Sensitivity to Increased Liquid Loading	Insensitive	Very sensitive	Medium	Medium	Medium
Sensitivity to Increased Flow Rate	Some to none	Very sensitive	Medium	Medium	Medium
Sensitivity to "Turn-Down"	Insensitive	Sensitive	Sensitive	Medium	Medium

Higher Liquid Capacity

By handling several times more liquid volume without liquid reentrainment in effluent gas, Pall coalescers reduce equipment problems downstream. Fewer and smaller cartridges mean a simpler, more compact system.

No Reentrainment of Liquids

The spacing of the cartridges enables Pall SepraSol liquid/gas coalescers to control the exit velocity of the gas, allowing the coalesced drops to drain effectively and not be reentrained in the effluent gas. The result is liquid-free gas.



Fuel gas burners that are fouled do not maintain a steady, consistent flame. *(Left)* A failed combustor housing. You should not have to replace fouled burner nozzles *(center)* with new ones *(right)* more often than once a year.

Pall AquaSep Plus and PhaseSep Coalescers for Separating Liquids from Liquids

Through better liquid/liquid separation, Pall can cure a variety of costly problems that may go undetected. If you experience any of these symptoms in your process, chances are Pall can help you reduce your costs.

- Hazy product (not bright and clear)
- Sodium levels in gasoline above 1 ppm
- High solvent losses downstream of liquid/liquid extraction units
- High caustic carryover from gasoline, LPG or kerosene treating units
- Carryover of amine in LPG
- Oil and hydrocarbon in water and other aqueous streams

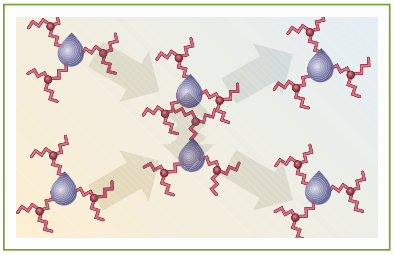
Defining the Problems

Liquid/liquid dispersions or emulsions are often formed by process operations such as liquid/liquid extraction and water washing. As liquid mixtures cool, the solubility decreases. In the case of steam stripped hydrocarbons, for example, as the temperature decreases, water condenses to form a second distinct liquid phase, resulting in hazy product. Also, oil becomes dispersed in water causing problems in wastewater treatment plants, steam systems, and in produced water from oil drilling.

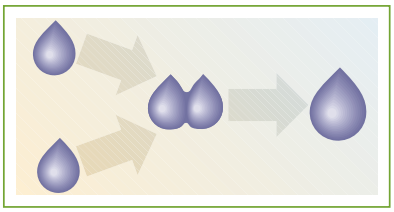
Separating these liquids can be difficult, depending on the physical properties of each. One of the most important properties to address in sizing and selecting coalescers is interfacial tension. Pall coalescers can handle a broad range of interfacial tensions.

Interfacial Tension

The lower the interfacial tension, the more stable the emulsion and the more difficult the liquids are to separate. Frequently, the problem is the presence of a surfactant which lowers interfacial tension. Conventional coalescers begin to lose efficiency when the interfacial tension is below 20 dyne/cm. In addition, a small amount of surfactant can disarm conventional coalescers, rendering them ineffective. Surfactants are everywhere — in corrosion inhibitors, organic acids, well treating chemicals, sulfur compounds, and numerous chemical additives. Pall AquaSep Plus and PhaseSep coalescers separate liquids with interfacial tensions as low as 0.5 dyne/cm.



Impact of surfactants on coalescing.



No surfactant – coalescing is less difficult.

An AquaSep Plus liquid/liquid coalescer eliminates haze problems from refinery fuels like gasoline, diesel, and jet fuels.

Comparison of Liquid/Liquid Separation Equipment

Pall coalescers offer significant benefits over other separation technologies, as shown in the table below.

	Pall AquaSep Plus/ PhaseSep Coalescer System	Salt and Desiccant Tower	Conventional Coalescers	Mesh Pack	Electrostatic Precipitator	Tank Settling	Vacuum Dehydration Tower
Lowest interfacial tension efficiently separated	AquaSep Coalescer: 3 dyne/cm PhaseSep Coalescer: 0.5 dyne/cm	<2 dyne/cm	>20 dyne/cm	>20 dyne/cm	>10 dyne/cm	>20 dyne/cm	<2 dyne/cm
Relative operating and maintenance costs	Low	High	Medium	Low	High	Low	High
Effect of additional dispersed liquid on operating cost	Low	High	Low	Low	High	Low	Medium
Effect of surface active chemicals on efficiency	None	None	Reduces efficiency	Reduces efficiency	Reduces efficiency	Reduces efficiency	None
Effect of additional dispersed liquid on efficiency	Low	Medium	Low	High	Medium	Medium	Medium
Sensitivity to temperature changes	Low	Medium	Low	Low	High	Low	Low
Relative maintenance	Low	High	Medium	Low	High	Low	Medium

Pall's AquaSep Plus and PhaseSep liquid/liquid coalescers separate water from hazy diesel and oil from wastewater, providing contaminant-free products.

Open here for a complete selection guide for coalescer part numbers/ordering information

Two Configurations for Optimum Separation Efficiency

Pall's AquaSep Plus coalescers and PhaseSep coalescer systems are available in horizontal and vertical configurations. Determining the correct configuration depends on the liquids in your process. Both configurations begin with a prefiltration stage to remove solid contaminants. This significantly extends service life, improves the fluid quality, and decreases the stability of liquid/liquid emulsions, making coalescing easier.

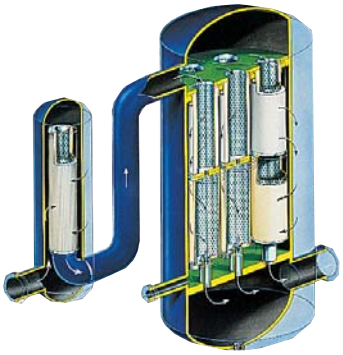
Pall's Patented Vertical Coalescer/Separator Stack

This is Pall's most efficient technique for separating two liquids when the dispersed fluid is water and the interfacial tension is greater than 3 dyne/cm. The coalescer elements are stacked on top of a separator element to ensure uniform flow distribution from the coalescer to the separator. The assembly is smaller and has a longer service life than conventional coalescers. After water droplets are coalesced in Pall's proprietary media, water-free liquid and large droplets of water flow toward the separator. The hydrophobic separator medium repels the aqueous phase, so only the water-free bulk fluid passes through the separator. The two liquids are removed by separate drain connections.

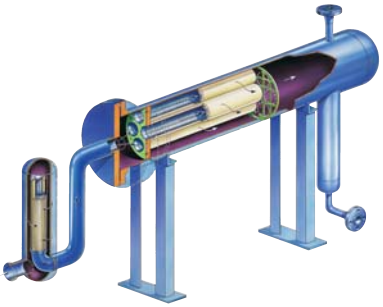
The Pall Horizontal Coalescer

If the dispersed liquid phase is not water, an AquaSep Plus coalescer or PhaseSep coalescer without a separator is placed in a horizontal housing. It should be used to separate oil from water, two non-aqueous liquids, or when the interfacial tension of two liquids is less than 3 dyne/cm.

In this configuration, the liquid/liquid mixture enters the coalescing element and flows inside to out. Small liquid contaminant droplets coalesce into larger droplets which are separated by gravity and are removed.



Pall vertical liquid/liquid coalescer
Configuration with prefilter on the left and AquaSep Plus/PhaseSep coalescer shown far right. Water exits bottom left, water-free product exits bottom right.



Pall horizontal liquid/liquid coalescer
Configuration with prefilter far left and AquaSep Plus/PhaseSep coalescer shown right. Contaminant-free continuous phase exits top right, liquid contaminant exits bottom right.

Pall's AquaSep Plus coalescer and PhaseSep coalescer stack assembly

Fortunately, for each problem there is a solution:

Pall SepraSol Liquid/Gas Coalescers

Description	Part Number	Dimensions	Special Features	Applications
SepraSol Single Open-ended Coalescer	CC3LGA7H13	762 mm (30 in) length 70 mm (2.75 in) diam.	Polyester drainage layer	Low pressure; low liquid load

SepraSol Amine Coalescer	CC3LGB7H13	762 mm (30 in) length 70 mm (2.75 in) diam.	Polypropylene drainage layer	Recovery of carried over amine; recovery of oil from ammonia gas

SepraSol Double Open-ended Coalescer	CC3LG02H13	762 mm (30 in) length 70 mm (2.75 in) diam.	Tie-rod seal; acetal endcaps	Pressure greater than 13.8 bar (200 psi); low liquid load; greater than 5% aromatics in liquid

SepraSol Plus Coalescer	CS604LGH13	1016 mm (40 in) length 153 mm (6 in) diam.	High liquid pack design; stainless steel endcaps	Liquid loading over 100 ppmw

Equipment service life between maintenance shutdowns and plant turnarounds is often shorter than it could be. The causes of increased maintenance and operating costs are not always obvious. The following tables present common symptoms that lead to costly problems in various plant applications. A brief summary of Pall's liquid/gas and liquid/liquid coalescers is offered as long-term cost saving solutions.

Inadequate liquid removal can create costly maintenance and production problems.

Application	Symptom	Problem
Gas transmission compressors	Repairs needed in less than two years	Gas throughput below design; fouling and salting of compressor internals
Reciprocating hydrogen compressors	Repairs needed in less than two years	Gas throughput below design; fouling and salting of compressor internals
Amine or glycol contactors	More than two foaming incidents a year	Gas throughput lower than design; foaming in contactor, poor energy efficiency; fouling of exchanger and reboiler Condensable hydrocarbons in the inlet gas lower the surface tension of the amine and initiate foaming episodes
Fuel gas burners	Less than one year between maintenance	Burner nozzles plugged and frequently maintained; poor flame patterns
Desiccant or adsorbent bed	Less than three year change-out; regenerable adsorbent less than 20 years	Frequent regeneration problems; high pressure drop
Compressor lube oil in refinery, gas and chemical plants	Lube oil makeup greater than design	High lube oil makeup; fouling of downstream equipment with lube oil Off-spec product (e.g. ammonia)
Amine from contactors	Amine makeup at 2 lb/MMSCF greater than design High amine loss rate	Higher than design amine losses; fouling of downstream equipment
Gas separation membranes	Fouling in less than three years	Poor membrane separation efficiency; short service life

The solution is advanced technology:

Pall AquaSep Plus and PhaseSep Liquid/Liquid Coalescers

Description	Part Number	Dimensions	Special Features	Applications
AquaSep Plus Coalescer	LCS2B1AH LCS4B1AH	508 mm (20 in) length 1016 mm (40 in) length 95 mm (3.75 in) diam.	Polymeric medium does not disarm in presence of surfactants; integral prefilter	Separation of water from hydrocarbons

PhaseSep Coalescer	LCS2H1AH LCS4H1AH	508 mm (20 in) length 1016 mm (40 in) length 95 mm (3.75 in) diam.	Fluoropolymer medium has a wide range of chemical compatibility	Separation of caustic or amine from hydrocarbon; separation of hydrogen peroxide from working solution

PhaseSep Coalescer	LCS2H2HH LCS4H2HH	508 mm (20 in) length 1016 mm (40 in) length 95 mm (3.75 in) diam.	Broadest range of chemical compatibility	Many acid and solvent applications

Separator	LSS2F2H	508 mm (20 in) length 95 mm (3.75 in) diam.	Hydrophobic medium does not allow water to pass through	Separation of water from hydrocarbons

Poor separation can damage equipment and reduce product quality.

Application	Symptom - Measured Interfacial Tension	Problem
Separation of water from gasoline, jet fuel and diesel	3 - 25 dyne/cm	Haze problems cause off-spec product. Presence of surfactants, either existing in the feedstock or added to the system, reduce interfacial tension, increasing difficulty of water removal.
Separation of caustic from gasoline, jet fuel and diesel	0.5 - 13 dyne/cm	Presence of sulfur compounds result in very stable, difficult to separate emulsions
Separation of water from light hydrocarbons (C_6 and below) and petrochemicals	5 - 20 dyne/cm	Presence of surfactants, either existing in the feedstock or added to the system, reduces interfacial tension, increases difficulty of water removal.
Separation of amine from LPG	N/A - difficult to analyze	Liquid/liquid contactor typically the largest source of amine losses. Sulfur compounds contribute to stabilizing the emulsion, making separation more difficult.
Separation of hydrogen peroxide from working solution	20 - 35 dyne/cm	Inefficient phase separation
Separation of acids from petrochemicals and hydrocarbons	Wide range	Carryover of acids common in refinery and specialty chemical plants; small stable emulsions difficult to separate
Separation of oil from: **■ water**	Wide range	Oil will foul steam system and increase load to wastewater treatment plant
■ anhydrous ammonia		Off-spec anhydrous ammonia

Pall Liquid/Liquid Coalescer Selection Guide

Interfacial tension between liquids is another factor in determining the correct product and configuration for your process.

Process Condition	Recommended Product
Contaminating fluid is aqueous, IFT >3 dyne/cm	AquaSep Plus or PhaseSep coalescer/separator stack (vertical housing)
Contaminating fluid is aqueous, IFT <3 dyne/cm	AquaSep Plus or PhaseSep coalescer without separator (horizontal housing)
Both fluids are non-aqueous	AquaSep Plus or PhaseSep coalescer without separator (horizontal housing)
Contaminating fluid is oil, bulk fluid is water	AquaSep Plus or PhaseSep coalescer without separator (horizontal housing)

Pall Corporation — A Powerful Resource for Control, Protection, and Teamwork

Pall Corporation is a filtration, separation and purification leader providing solutions to meet the critical fluid management needs of customers across the broad spectrum of life sciences and industry. Pall works with customers to advance health, safety and environmentally responsible technologies. The Company's engineered products enable process and product innovation and minimize emissions and waste. Visit www.pall.com/green to see how Pall is helping enable a greener, safer, more sustainable future.

To learn more about our coalescing technology, contact your local Pall representative or visit us on the web at: **www.pall.com**.

Vertical AquaSep Plus liquid/liquid coalescer system removing water from kerosene.

Vertical AquaSep Plus liquid/liquid coalescer system removing water from jet fuel.

Horizontal PhaseSep liquid/liquid coalescer system removing caustic from gasoline.

Vertical AquaSep Plus liquid/liquid coalescer system removing water from diesel.

SepraSol liquid/gas coalescer system protecting a compressor.

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