



Pall Corporation

Pall Gas Solid Separation Systems



Advanced Metal and Ceramic Filter Systems
for Critical Gas Solid Separation Processes

Filtration. Separation. Solution.SM



Pall jet pulse blowback system utilizing AccuSep® tubular filters. Filter tubesheet with filters being installed into the pressure vessel.

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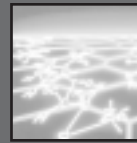
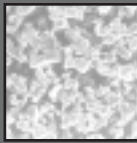
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PALL CORPORATION – A LEADER IN FILTRATION TECHNOLOGIES

Traditional equipment such as cyclones, baghouses, electrostatic precipitators, and scrubbers are not always able to satisfy the industry's demand for the most efficient, economical, safe, and energy-conserving gas solid separation processes. Pall Corporation's Gas Solid Separation (GSS) systems are used by hundreds of customers because they can meet these requirements.

At the heart of the Pall GSS system is a sintered porous metal or ceramic filter element. Pall's inorganic filter medium is designed for surface filtration. It can withstand temperatures from 232°C (450°F) to 1000°C (1832°F) and pressures in excess of 1000 psid (69 barg) without altering filtration characteristics.

The filter medium actually serves as a septum in that it provides a surface on which a cake of particles forms. This particle layer will continue to build until a predetermined pressure drop — a function of cake thickness and compressibility — is reached. A reverse flow of clean gas (blowback) is then introduced to dislodge the filter cake. 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 dispatched to a collection unit.

The GSS system reflects Pall's leadership in filtration technology, which has spanned over 60 years. Our innovations include the following.

- A patented method for sintering stainless steel powder that is the basis for our PSS® porous metal elements.
- The invention of, and ownership of patents for, the world's first sintered metal fiber medium, which is the basis of our Dynalloy® porous metal fiber filters.
- The introduction of the AccuSep medium, which is based upon the US Department of Energy's economical inorganic membrane technology.
- A patented method for the manufacture of seamless sintered metal powder elements that does not require compression of the medium. Our S-Series PSS medium is based on this technology.
- A market leadership position for Pall's Dia-Schumalith® ceramic candle filters, which are suitable for applications requiring higher temperatures and greater corrosion resistance than elements made of sintered metal alloys can accommodate.

Dia-Schumalith ceramic elements are constructed using a silicon carbide powder with a proprietary binder.

Pall offers the broadest range of inorganic, high-temperature filter media in the industry. Regardless of your application, we can meet your requirements for optimum high-temperature, self-cleaning, blowback filter elements.

All high-temperature GSS elements satisfy the following requirements.

- Optimum pore size distribution to allow particles to collect on the filter surface and to prevent particles from penetrating into the medium.
- Pore size uniformity for full utilization of the filter surface.
- Fixed pore structure to prevent media migration.
- Physical strength and durability to withstand the cyclic loads applied during reverse flow cleaning cycles.
- Chemical and thermal compatibility with process conditions to ensure long life.

Pall is a highly integrated manufacturer and an industry leader. The range of our capabilities, from filter manufacturing to the fabrication of complete, automated filtration systems, is broader than that of any other company in the industry. We design our GSS systems for the specific rigors of each application and provide assistance with system start-up.

PALL FILTER MEDIA

Pall offers the largest variety of filter media, element sizes and configurations, and filter grades. Choosing the best filter element for your application depends largely on the process conditions, solids loading, gas composition, maximum allowable pressure drop, and the characteristics of the filter medium. Inorganic media is inherently strong and durable for long-term service.

Table 1 details the construction and performance attributes of each medium.

Table 1. Performance attributes of Pall blowback filters¹

| Medium | Materials of Construction | Typical Outer Diameters (in/mm) ² | Application Benefit |
|---|--|--|--|
| AccuSep powder metal medium | 316L | 0.72/18.3 | <ul style="list-style-type: none"> • Finest removal rating • Smallest vessel diameter • Not susceptible to thermal shock • Fixed pore structures |
| Seamless S-Series PSS powder metal medium | 316L 310SC Hastelloy ³ X Inconel ⁴ 600 Iron Aluminide | 2.375/60.3 | <ul style="list-style-type: none"> • Broad selection of materials • Greater permeability than the conventional PSS medium • Not susceptible to thermal shock • Fixed pore structures • Accommodates a wide range of hardware configurations |
| PSS powder metal medium | 304L 316L 310 SC Alloy 20 Hastelloy X Inconel 600 Monel ⁵ 400 | 2.375/60.3 | <ul style="list-style-type: none"> • Broadest selection of materials • Highest-strength rolled and welded filter elements • Not susceptible to thermal shock • Fixed pore structures • Accommodates a wide range of hardware configurations |
| Dynalloy fiber metal medium | 316L Hastelloy X Inconel 600 | 2.375/60.3 3.5/88.9 4.5/114.3 | <ul style="list-style-type: none"> • Highest permeability • Not susceptible to thermal shock • Fixed pore structures |
| Dia-Schumalith ceramic medium | Silicon carbide/alumina Mullite | 2.36/59.9 | <ul style="list-style-type: none"> • Highest temperature capability • Fixed pore structures |

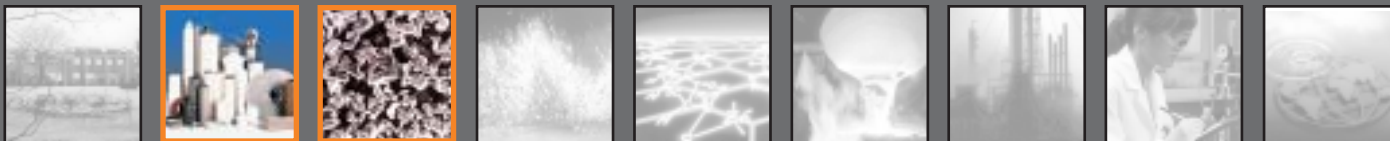
¹ The information in Table 1 is provided to assist you in filter selection and should be used as a guide only.

² Other diameters available upon request.

³ Hastelloy is a registered trademark of Haynes International, Inc.

^{4, 5} Inconel and Monel are registered trademarks of the Special Metals Corporation group of companies.

Installation of GSS filter element into a 48" diameter tube sheet assembly.



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PALL FILTER MEDIA

Table 2 provides compatibility information for the various Pall blowback filter media.

Table 2. Materials of Construction

| | Chloride-Bearing | Sulfur-Bearing | Oxidizing Acids | Salts Seawater Brine | Caustic | Mixed-Gas Carburizing | Oxidizing Atmosphere | Reducing Atmosphere |
|--------|------------------|----------------|-----------------|----------------------|----------------|-----------------------|----------------------|---------------------|
| 1000°C | Dia-Schumalith | | | | Dia-Schumalith | | | |
| 900°C | Hastelloy X | | | | | Hastelloy X | Hastelloy X | |
| 800°C | | Iron aluminide | | | | Iron aluminide | Iron aluminide | Iron aluminide |
| 750°C | | | | | | Dia-Schumalith | Dia-Schumalith | |
| 700°C | | | | | | | | Hastelloy X |
| 650°C | | 310 SC | | Nickel 201 | Nickel 201 | 310 SC | 310 SC | 310 SC |
| 600°C | | | | | | | | Dia-Schumalith |
| 550°C | Inconel 600 | | | | | Inconel 600 | Inconel 600 | |
| 500°C | C-276 | | | | | | | |
| 420°C | | 316L | | | | 316L | 316L | 316L |
| 300°C | | | Nickel 200 | Nickel 200 | Nickel 200 | | | |
| 250°C | Alloy 20 | Alloy 20 | | 347 | 316L | | | |
| 125°C | C-22 | | 316L | | | | | |

Note: The information in Table 2 is based on Pall testing, field experience, and literature. It is provided to assist you in filter selection and should be used as a guide only.

All of Pall's high-temperature media have the following properties.

High particulate removal efficiency

- Typical removal >99.99%.
- Fixed pore structures.
- Efficiency does not degrade in service.
- No media migration, even during process upsets.

High permeability

- Void volume of media varies from 40% to >75%.
An important advantage of Pall Dynalloy metal fiber medium is that it exhibits a much lower differential pressure than any other Pall metallic medium. This results in the buildup of a lower density cake, which releases more easily with back pressure. It also helps achieve pressure equilibrium faster, at a much lower pressure, and minimizes the possibility of particulate impaction and penetration into the filter medium.
- Seamless S-Series PSS sintered metal powder elements are made using a patented centrifugal casting method, not a pressing operation. This yields a powder metal element with higher permeability and greater uniformity of flow.

Temperature resistance

- The widest range of temperature compatibilities is available because Pall offers the largest variety of medium compositions.
- The combination of the silicon carbide support body and alumina membrane in a Dia-Schumalith element guarantees a low differential pressure at high flux rates.

Corrosion resistance

- Pall's sintering process retains the corrosion-resistant properties of the base alloys.
- At temperatures >650°C (1200°F), Dia-Schumalith ceramic elements exhibit a wider range of corrosion resistance than many of their metallic counterparts.

Element integrity

- Each element undergoes a nondestructive bubble point test before shipment to certify element integrity and efficiency rating.
- Medium thickness is optimized for maximum element strength and minimum pressure drop.

ROBUST ELEMENT DESIGN

For maximum strength, the Pall Dynalloy, PSS, and S-PSS sintered metal elements are made of sections joined by welding solid joiner rings to the sintered porous metal tubes. The element is closed at one end by a welded end cap. A suitable adapter is welded to the open end for attachment to a tube sheet. Solid hardware is typically constructed of 304 stainless steel, but 310S stainless steel is used for high-temperature applications. Upon request, special alloys can be used.

Pall blowback filters are available in various formats to leverage media properties and ensure cost effectiveness.

Table 3. Element formats

| | Metal Bag | Triad/Assembly | Individual Elements |
|-----------------------|--------------------------|--|--|
| Available Media | Dynalloy filter elements | <ul style="list-style-type: none"> • S-PSS filter elements (seamless tubes) • PSS filter elements • AccuSep filter elements | <ul style="list-style-type: none"> • Dynalloy filter elements • S-PSS filter elements • PSS filter elements • Dia-Schumalith³ filter elements |
| Application Guideline | Terminal dP ≤ 1 psid | Terminal dP ≥ 1 psid | Varies depending on construction |

³ Individual Dia-Schumalith filter elements are typically mounted in a small tube sheet cluster. Many tube sheet clusters are then installed in a larger pressure vessel.



Triad element design

Sintered metal elements are banded together in groups of three to form rugged triads. The triad design guarantees effective tube sheet packing and enables the elements to withstand the rigors of process-upset conditions, thermal deviations, and vibrational forces.

Tube sheet adapter

The elements can be welded, threaded, or flanged to the tube sheet. A welded connection ensures that there is no bypass of solids and is typically used in critical, high temperature applications. A threaded or flanged connection eases assembly and maintenance operations and is typically used on noncyclic, lower-temperature applications.

Support grid locating pins

Pins are welded to the bottom solid end cap and are used to locate the sintered metal element in a support grid. Sufficient lateral and axial clearance is provided to accommodate thermal expansion and contraction of the elements during start-up, normal operation, and shut-down. The support grid is an integral component of the filter assembly. It provides lateral support and minimizes element vibration during operation.

Fail-safe fuse

For critical applications, where the bypass of any particles can have serious consequences on downstream equipment, Pall's proprietary fail-safe fuse is available as an option. In the rare event of a filter element failure, this small last-chance filter permits continued operation without particle bypass.

The fuse is constructed of a coarse grade medium. It is usually of the same composition as the primary element, designed for negligible pressure drop, and built to withstand a failure of the primary filter element. The coarse grade medium quickly plugs with solids, resulting in an effective seal. For large systems, the loss of a single element in an assembly results in an insignificant increase in pressure drop or loss of process capacity. The filter remains in service, providing the same protection to downstream processes, equipment, and the environment.



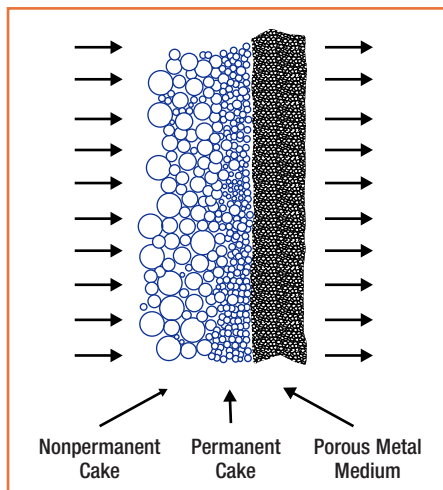


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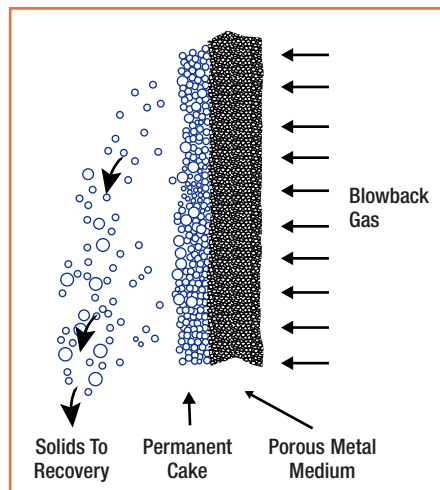
HOW THE PALL GSS SYSTEM WORKS

Pall GSS filter systems are designed to remove particulate matter from gas streams. To accomplish this, sintered metal or ceramic filter elements with sufficiently small pores, and sized at an appropriate flow rate per unit of filter area (flux), retain solids at or near the filter surface. As a result, a permeable cake of solids forms. The cake is dislodged at a pre-determined pressure drop (a function of cake thickness and compressibility) by initiating a reverse flow. The dislodged solids are purged from the filter system. They may be returned directly to the process for reuse or removed from the process stream and sent to a storage or collection unit. After the blowback cycle, a fine layer of particles remains on the filter medium, assisting the filter by acting as a fine protective coat. The filter then returns to full forward flow and to an initial pressure drop that will remain essentially constant through thousands of blowback cycles.

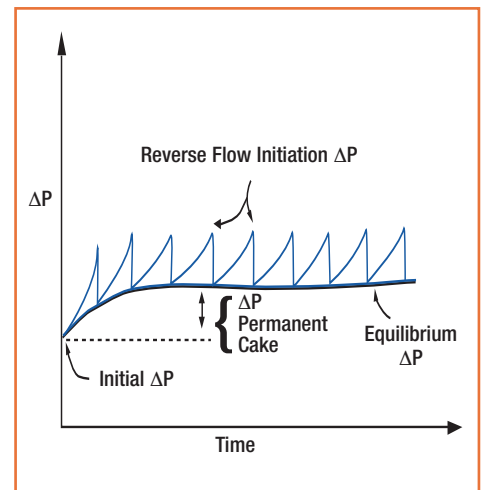
Cake formation and release



Hypothetical Cake Structure



Hypothetical Cake Release



Differential Pressure vs. Time

Sequence of actual cake formation and release



Pall porous metal filter element before use.



Element cake with fine solids prior to blowback.



Reverse flow effectively dislodges nonpermanent cake.



Element with permanent cake ready for resumption of forward flow.

Pall Gas Solid Separation Systems

Advanced Metal and Ceramic Filter Systems for Critical Gas Solid Separation Processes

Regeneration methods

The Pall GSS system is designed to provide the optimal arrangement of blowback filter elements within vessels. Automated controls, instrumentation, valving, and inter-connecting piping are included in our system package. The Pall GSS system is the technical and economical solution for high efficiency, reliability, and safe separation of solids from process gas streams under the following specified conditions.

- High temperature—up to 1000°C (1832°F)
- Vacuum to high system pressures—from near 0 (zero) to 1000 psid/69 bard
- High solids loading—in excess of 0.1 lb/ft³ (1.6 kg/m³ gas)
- Corrosive gas environments

Reverse flow blowback

GSS systems utilizing reverse flow blowback regeneration employ one or more vessels for continuous process flow. To clean the filter elements when the terminal pressure drop is reached, an entire vessel, or a section of the vessel, is isolated by closing the inlet and outlet valves.

Reverse flow blowback is the preferred method for low-density contaminants or when high-pressure blowback gas is not readily available. With low-density contaminants, the low-pressure reverse gas prevents re-entrainment of the particles back onto the filter elements when forward flow resumes.

Jet pulse blowback

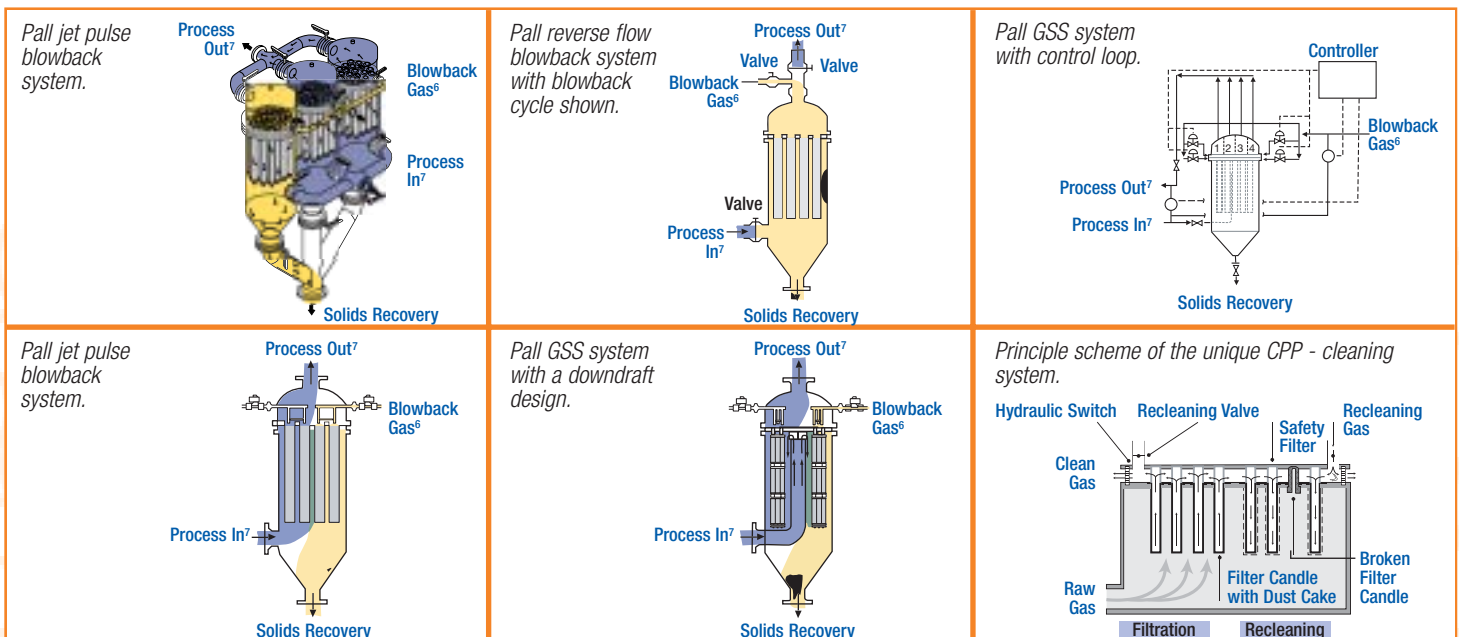
The jet pulse method also uses one or more vessels. Full forward flow is maintained at all times, eliminating the need for large, costly vessel isolation valves. Groups of elements are blown back sequentially by directing a high-pressure pulse of gas into the throat of each element. The shock wave set up by the reverse pulse, enhanced by the venturi in the element throat, effectively removes the accumulated cake.

Jet pulse blowback is the method of choice for solids that settle quickly after being dislodged from the filter elements. This method eliminates the need for isolation valves and results in significant cost savings, especially in high temperature applications.

Coupled pressure pulse (CPP) blowback

The CPP cleaning method is based upon the direct coupling of the blowback gas reservoir and the filter elements. The filter elements are separated into groups by dividing the clean gas area into several cells. These groups are cleaned sequentially. Gas enters the vessel via the raw gas inlet port and flows through the filter elements, an optional fuse, and the hydraulic switch.

Element groups are cleaned when the recleaning valve is opened, allowing gas from the blowback gas reservoir to flow through the filter elements. The pressure of the blowback gas is only 14.5-29 psig (0.1 to 0.2 MPa) higher than the operating pressure. The low permeability of the hydraulic switch during the backpulse prevents the blowback gas from exiting with the clean gas.



⁶ Blowback Gas (yellow)

⁷ Process Gas (blue)



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SYSTEM BENEFITS

Applications of Pall GSS systems

A Pall GSS system can either be installed as a new system or to retrofit existing conventional equipment such as cyclones, baghouses, scrubbers, or electrostatic precipitators. The superior capabilities of Pall GSS systems over other types of equipment are shown in Table 4.

Table 4. Comparison of the Pall GSS system with conventional equipment

| | Pall GSS | Cyclone | Baghouse | Scrubber | Electrostatic Precipitator |
|--|---|------------------|------------------|----------------|----------------------------|
| Efficiency of solid separation from gas stream | >99.99% | 98% | 99.9% | 99% | 99% |
| Maximum operating temperature | 900°C ⁸ (1650°F) 1000°C ⁹ (1832°F) | >1093°C (2000°F) | 232°C (450°F) | 232°C (450°F) | 482°C (900°F) |
| Relative operating pressure drop | Medium | Medium | Medium | High | Low |
| Separation efficiency sensitivity to solid loading | No | Yes | No | Yes | Yes |
| 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 |
| Solid loading reduction prior to final separation required | No | No | Yes | Yes | Yes |
| Reliability and safety of operation | High | High | Low | Medium | Medium |

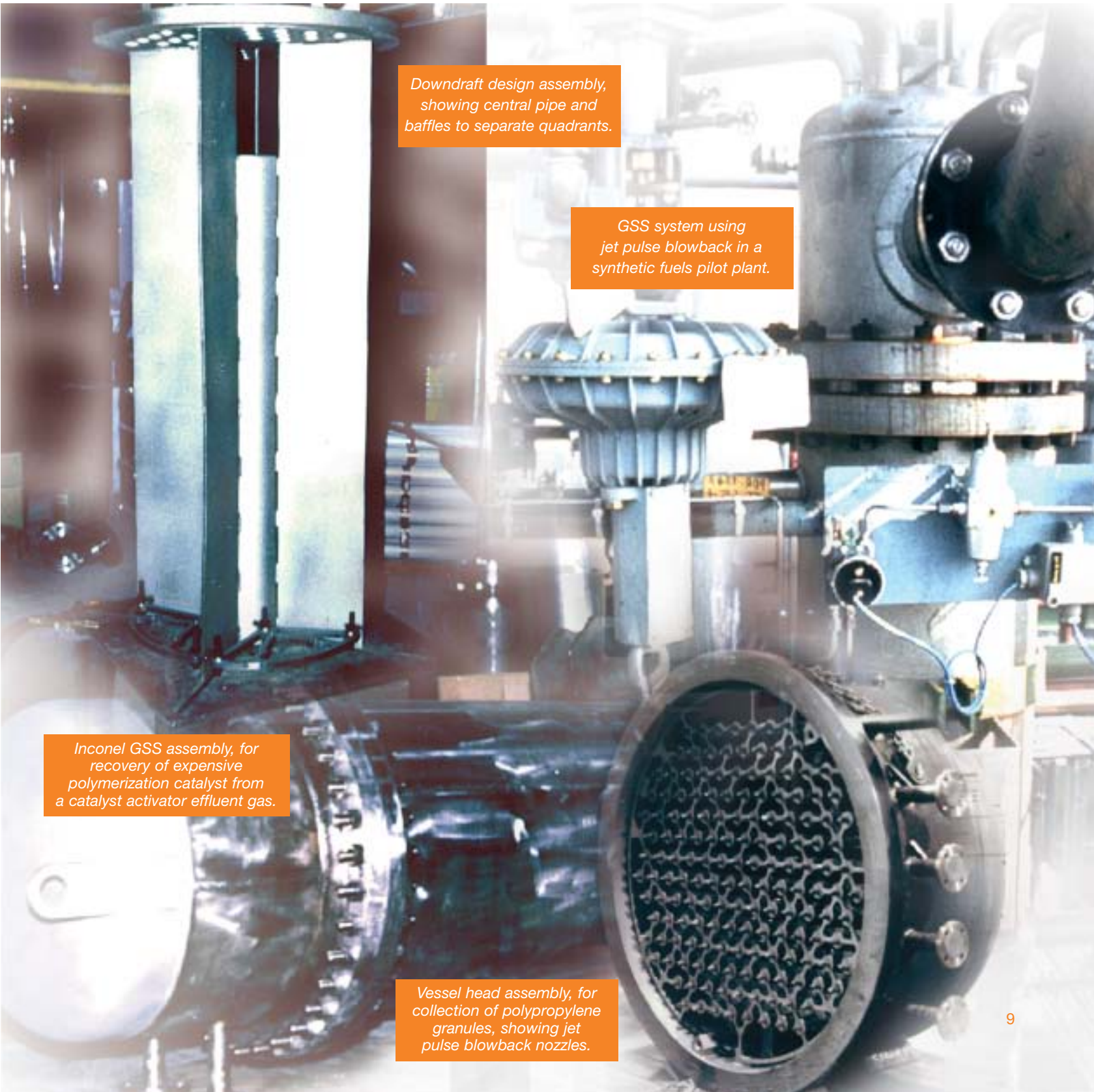
⁸ Sintered metal construction

⁹ Dia-Schumalith ceramic construction

Pall Gas Solid Separation Systems

Advanced Metal and Ceramic Filter Systems for Critical Gas Solid Separation Processes

SYSTEM COMPONENTS

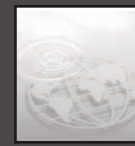
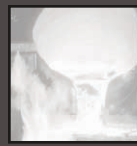
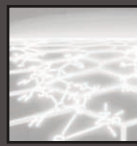
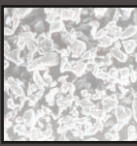
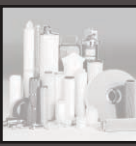


Downdraft design assembly, showing central pipe and baffles to separate quadrants.

GSS system using jet pulse blowback in a synthetic fuels pilot plant.

Inconel GSS assembly, for recovery of expensive polymerization catalyst from a catalyst activator effluent gas.

Vessel head assembly, for collection of polypropylene granules, showing jet pulse blowback nozzles.



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TYPICAL APPLICATIONS

Chemical Process Industries

Fluid bed reactor processes are widely used in the chemical process industry. Fine powdered catalysts are costly and are typically recovered from the reactor effluent stream by multiple stages of cyclones. The solid separation efficiency of a Pall GSS system is at least 99.99%, compared with about 99% for a multistage cyclone system.

Typical products produced in fluid bed reactors

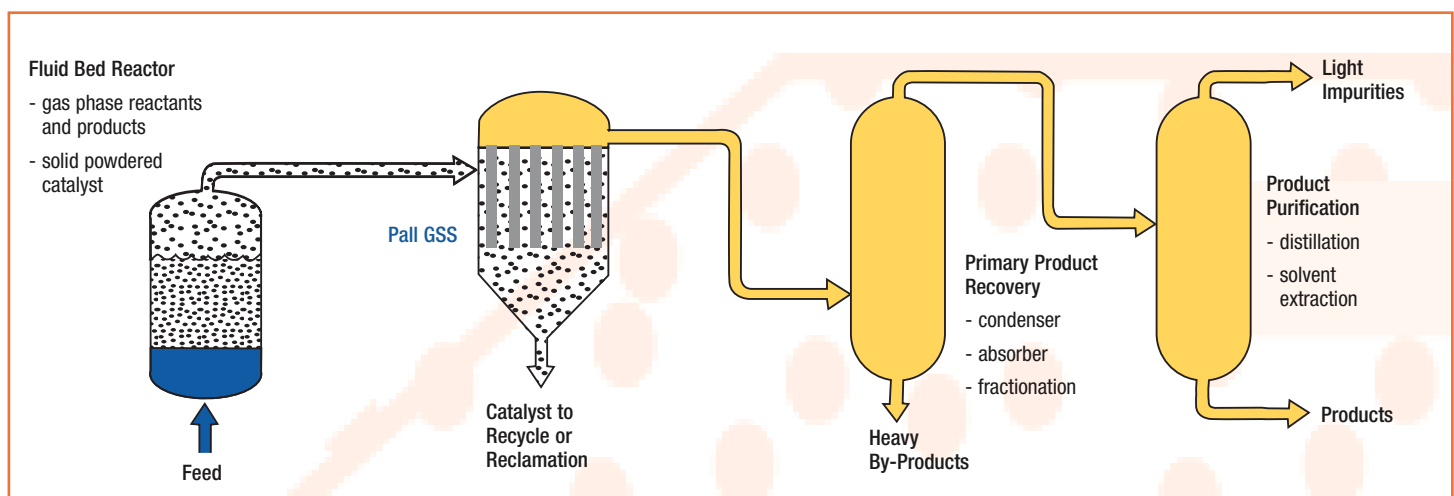
- Phthalic anhydride
- Maleic anhydride
- Acrylonitrile
- MTBE
- Isophthalonitrile
- Vinyl chloride
- Aniline



Benefits of the Pall GSS system

- Compared with cyclones, a one-hundred-fold reduction in the loss of expensive catalyst, providing a short payback period—typically less than one year. Helps maintain catalyst activity by recycling catalyst fines to the reactor.
- Dipleg plugging and trickle valve erosion and bypassing, intrinsic to cyclones, are eliminated. This increases reactor reliability and reduces maintenance requirements.
- Reactor throughput can be increased without incurring an increase in catalyst losses.
- Downstream product recovery and purification equipment is protected from entrained solids that cause fouling, plugging, and erosion of equipment components.

Fluid bed reactor train for chemical production



TYPICAL APPLICATIONS

Oil Refining Industry

In fluid catalytic cracking (FCC), continuous catalytic reformer (CCR), and S-zorb¹⁰ sulphur removal technology (SRT) processes, there are several gas solid separation applications for which the Pall GSS system is most effective. The high separation efficiency and temperature capabilities of a GSS filter provide the following benefits.

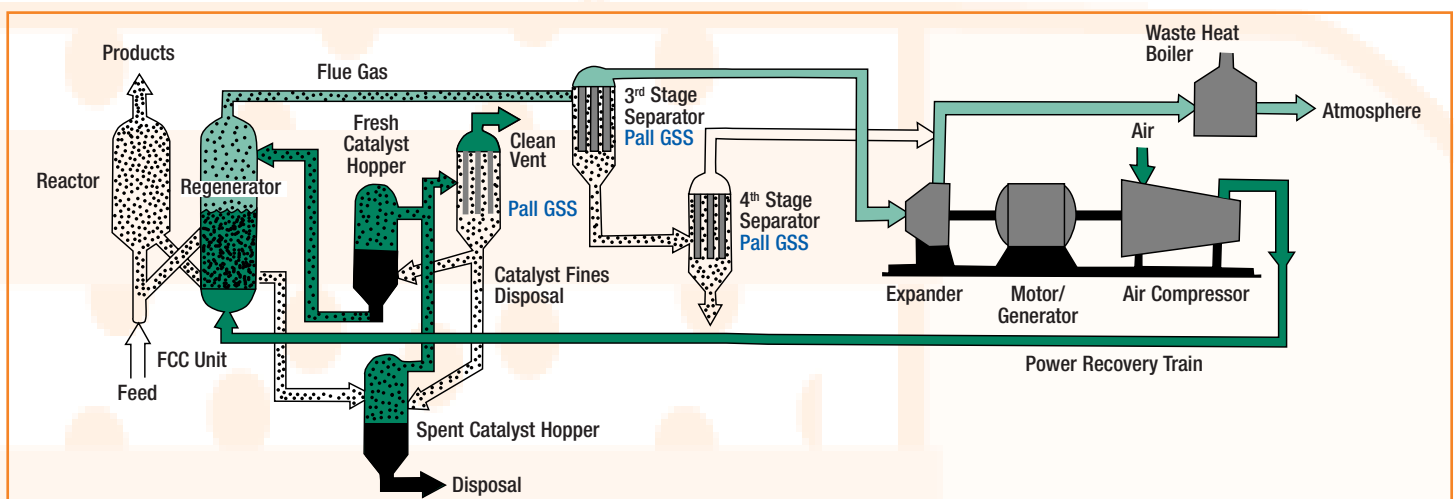
- Full compliance with the strictest government atmospheric particulate emissions standards.
- Optimal protection of turbo expander and heat exchange equipment from erosion and fouling caused by entrained catalyst fines in the FCC regenerator or flue gas.



Benefits of the Pall GSS system

- Particulate emissions are significantly reduced by replacing the cyclone and baghouse typically used in the third-stage underflow circuit (also called the fourth-stage separator) with a Pall GSS system.
- By replacing a cyclone with a Pall GSS system, removal efficiency is increased from 75% to 99.99%. In many cases this will allow the refinery to meet the required emissions standards.
- Using a Pall GSS system to retrofit the cyclones used in the third separator provides the best available protection of the turbo expander from erosion or from fouling by catalyst fines. It also reduces the maintenance requirements of the expander and increases its efficiency. The waste heat boiler is protected from fouling, thereby improving its thermal efficiency. In addition, an electrostatic precipitator or baghouse is no longer needed for final particle control prior to discharge to the atmosphere.
- Use of a GSS system on the vent gas from the catalyst storage hoppers provides high efficiency and trouble-free separation of catalyst fines during conveying operations. One GSS system installed on a common vent header virtually eliminates catalyst loading and unloading operations as a source of particulate emissions.

Fluid catalytic cracking unit



¹⁰ S-zorb is a trademark of Conoco Phillips.



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TYPICAL APPLICATIONS

Mineral Processing and Related Industries

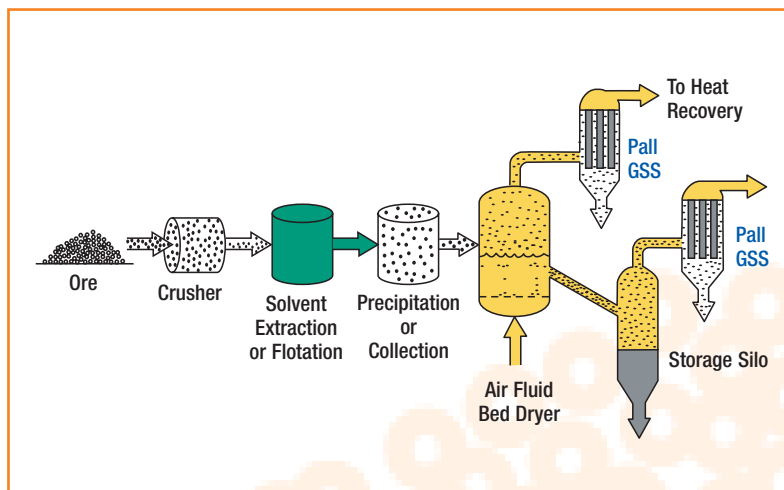
In the mineral processing industry, as well as in related industries such as nuclear fuel manufacture and catalyst production, solid intermediates and products are regularly handled in fine powder form. There is a need to recover these powders from the off-gases of such sources as calciners, fluid bed dryers, incinerators, and storage silos.

Benefits of the Pall GSS system

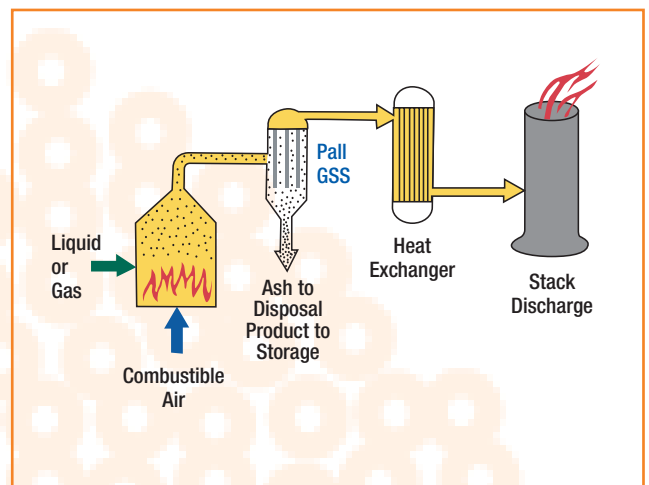
- High collection efficiencies of valuable products.
- Extremely low atmospheric emissions of radioactive or pyrophoric materials, such as aluminum powder.
- High level of safety in handling pyrophoric or explosion-prone powders because of effective flame-arresting characteristics.
- Reduced possibility of electrostatic sparks—known to occur in fabric baghouses—because the porous metal filters are fully grounded.
- Compliance with all atmospheric particulate emission standards.
- Improved thermal efficiency resulting from the ability to recover heat from a solid-free, high-temperature gas stream. Gas quench or other cooling, which is typically required prior to a baghouse or electrostatic precipitator, is not required with a GSS filter because of its superior temperature capabilities.



Typical mineral beneficiation process



Typical incinerator or furnace operation



PALL SERVICES

Pall's services, such as those described below, set us apart from other companies in the filtration field.

Unique scientific and laboratory services

Pall is committed to providing our customers with unsurpassed service. This means providing you with a high-quality product and delivering it promptly. It also means that we will make system recommendations, share scientific information, and provide effective solutions.

Pall Scientific and Laboratory Services (SLS) has a highly qualified staff of scientists and engineers who are supported by professional laboratory personnel and extensive, specialized laboratory facilities. A specific group of SLS technical specialists is dedicated to the refinery, minerals, and chemical process industries. Not only are they skilled in performing onsite testing but also, as a result of actual start-up experience, are able to relate test work to plant operations.

SLS staff scientists will work closely with you to solve difficult contamination control problems and to select the most efficient and economical Pall GSS system. This frequently involves extensive work in the SLS laboratories and, in some instances, at the customer site.

Pall technology services

We insist on complete customer satisfaction, and this commitment doesn't end when your Pall system is delivered. After delivery, a trained Pall technician will visit your plant and check all components thoroughly. The entire installation will be inspected carefully and completely to ensure that it conforms to specifications.

We will get you onstream as swiftly and efficiently as possible. To that end, Pall provides a start-up service that helps detect and eliminate "bugs." Our goal is to have you in full-scale production quickly.

Gas blowback testing laboratory

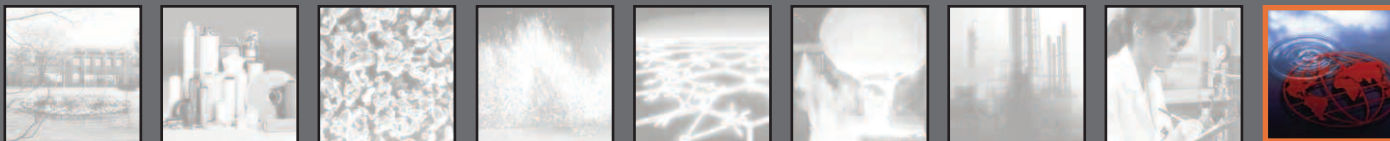
The Pall gas blowback test facility allows you to investigate potential savings in your present or proposed gas stream particle separation applications. Operating conditions can be simulated using the actual catalyst or contaminant that is to be removed. We develop a test program to evaluate a number of different Pall filter media over a range of blowback methods and cycles. This series of tests is devised to identify the optimum cost/performance criteria for your specific application. You can develop preliminary test data to justify further commitment of funds toward pilot or process level tests. A complete and detailed report is provided with each test.

Table 5. Gas blowback testing – facility specifications

| Pressure | Operating temperature |
|---|--|
| Plexiglass housing: 5 psid (0.34 bard) | Ambient temperature: 20°C (68°F) |
| Gas flow: 0 – 220 acfm | Test element: 60 - 64 mm (2.375" – 2.5") OD 1.22 m (48") long (maximum dimension) |
| Fluidizing gas: air [dew point <-59°C (<-75°F)] | |

Cleaning services for long-term performance

Should it ever become necessary to clean Pall porous metal or ceramic filters, take advantage of our expertise in the field. Backed by sophisticated testing equipment, Pall scientists and engineers can recommend effective cleaning procedures specific to your application.



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THE NEXT STEP

Whether your application is in a new market, or one that we currently serve, we invite you to share your challenges with us so we can help put Pall resources to work for you.

Contact Us

For more information on Pall GSS filter systems or any other Pall filtration products or systems, please contact your local Pall representative, or contact Pall directly.



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