CECO FILTERS

TECHNOLOGY • DESIGN • ENGINEERING

# *Innovative Filter Designs for the Chemical Processing Industry*

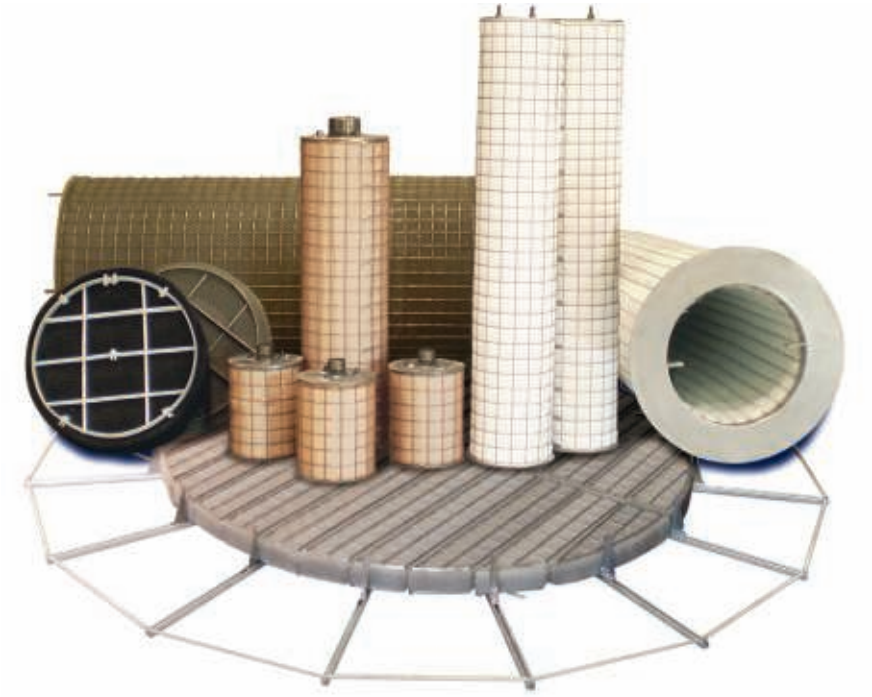
## *CECO Fiber Bed Filters*

CECO offers a complete line of fiber bed mist eliminators and systems to abate liquid mist emissions. Our fiber bed mist eliminators, also referred to as fiber bed filters or candle filters, are optimal for removing sub-micron liquid aerosols from gas and air streams. CECO's technologies are used extensively by facilities seeking to reduce emissions in a wide range of industries and applications.

Fiber bed filters are used to capture and remove liquid and soluble solid particulate from gas streams. Collection efficiencies as high as 99.9% can be achieved. Air streams and process gases can be made free of pollution or hazard problems and valuable material can be collected even in heavy liquid loading situations.

CECO designs and manufactures fiber bed coalescing filters used in a wide range of processing applications and industries to reduce and eliminate liquid mist and aerosol emissions. CECO fiber bed filters are available in standard or custom-designed configurations designed into new installations or as replacement media solutions for existing systems. Our fiber bed coalescing filter elements offer long filter life and simplified maintenance.

The CECO fiber bed filter elements are manufactured by CECO Filters employees, in our own manufacturing facilities, according to the highest quality control and manufacturing standards. Upon completion of assembly each filter element is individually tested for pressure drop, aerosol removal efficiency, and flow distribution.



## Fiber Bed Filter Construction

CECO's Fiber Bed Filters can be constructed of various corrosion resistant materials depending on the process conditions. These materials include Hastelloy, Alloy 20, 316L Stainless Steel, Tantalum, FRP, and thermoplastics, as well as standard carbon steel. Filters are typically constructed in annular cylindrical form with lengths from 2 to 20 ft. (0.6 to 6.1 m). The cylinder is formed by rolled screens of metal or thermoplastics. An outer and inner screen are used.

The filter media, selected from a wide range of materials, is placed between the inner and outer cylindrical screens to form the fiber bed. The diameter of the fibers, material, and packing density determine the parameters of the filter, such as pressure drop, collection efficiency, and gas volumetric flow rate. Plates and flanges are attached to the ends to permit a variety of mounting and draining methods.

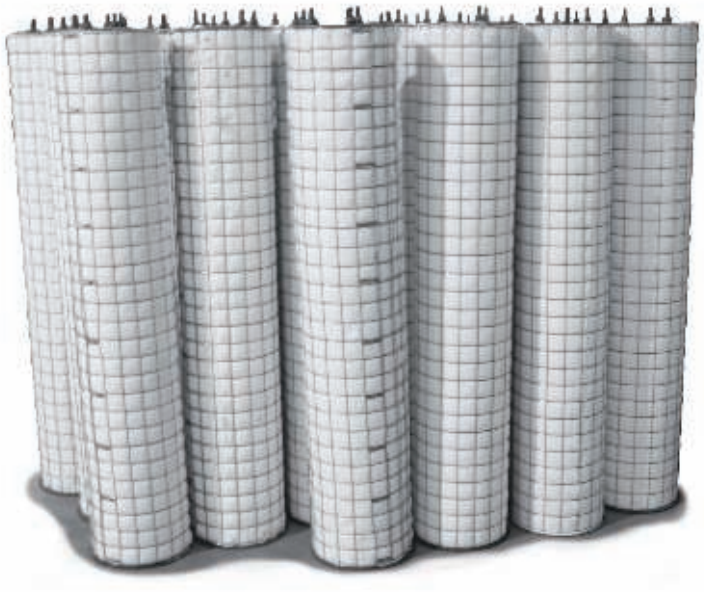
## Filter Process

The mist laden process gas passes in a radial, horizontal direction perpendicular to one side of the filter bed and cleaned gas exits from the opposite side. The aerosol is captured and held by the fibers. The collected liquid particles are coalesced into larger droplets on the filter's fiber surface and drain from the media by gravity once the mass of the particle is great enough to allow the droplet to flow.

Particles are collected by a combination of mechanisms: Impaction, Interception and Brownian Diffusion. Collection of particles less than 2 microns is primarily due to the Brownian movement; a mechanism somewhat unique to the fiber bed filter.

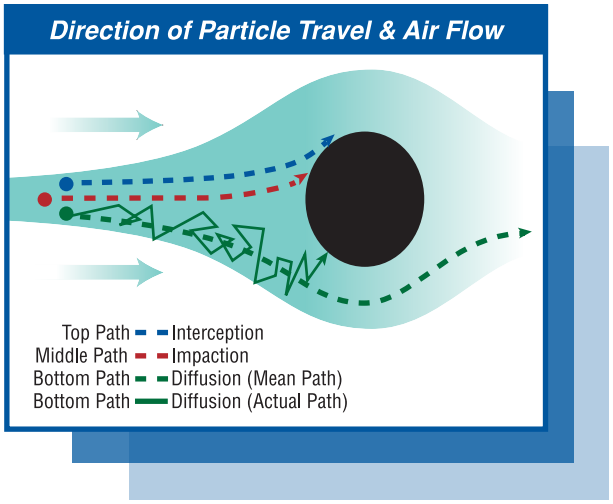
## CECO Fiber Bed Coalescing Filters Offer:

- High Removal Performance Efficiency
- Long Filter Life – Up to 10 Years
- Increased Surface Area
- Low Operating Costs
- Low Maintenance Costs
- Filter re-packing services, either on-site or at CECO's facilities
- Custom Designed filters for any new or existing systems



## Patented TWIN-PAK® Nested Filters

In 1990 CECO developed the innovative TWIN-PAK® nested design of a filter-inside-a-filter. By taking advantage of the unused space inside the annular area of a standard filter element, we can increase the surface area of the fiber bed element to up to 60%. For new installations this can allow the vessel housing to be much smaller, thus saving capital dollars. In the case of an expansion, the existing unit can be retrofitted to accommodate up to 60% more gas flow with the same mist eliminator vessel.




De-bottlenecking existing filter systems can be difficult and expensive if the filter vessel must be modified to accept taller filters or a greater number of filters. CECO Filters Patented TWIN-PAK® has been used to retrofit existing sulfuric acid absorption towers and other chemical process systems, increasing throughput and decreasing system pressure drop, without modification of the filter vessels.

## CECO Graded Bed Filters

For applications requiring a high removal efficiency for a given pressure drop or for high inlet loadings, CECO Filters Graded Bed Filters provide superior performance with higher sub-micron particle collection efficiency and deeper loading into the media bed for extended element life. This combined with the patented TWIN-PAK® nested filter design, allows CECO Filters to bring fiber bed technology to a new level of efficiency, performance and element longevity.

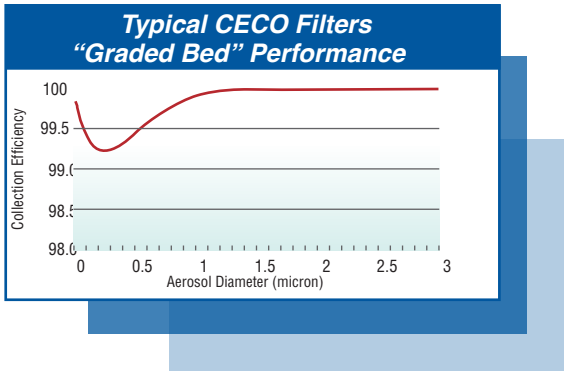
A Graded Bed filter consists of a media bed that is constructed of multiple layers of different types of media, each with a specific quality. In the CECO Filters Graded Bed filter we employ two or more types of media per bed. Of course, we employ the time tested rope wound media for high collection efficiency of the sub-micron droplets. What sets CECO Filters Graded Bed apart is that we employ a first layer of a blanket media for uniform gas distribution and solid particle depth loading.

When challenged with sub-micron aerosol particle collection applications such as after Sulfuric Acid absorption towers where Sulfuric Acid particles range between 0.2 and 1 micron, the CECO Graded Bed filter has proven to provide higher collection efficiencies at lower pressure drops while eliminating the problem of premature filter blinding.

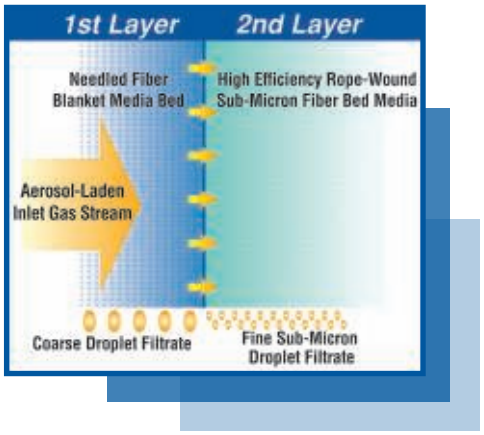
Industry-wide focus on eliminating visible plumes has resulted in a requirement for increased monitoring of stack discharge to control opacity. Often, visible plumes are caused by a slight sag, slump or “worm hole” in the fiber bed media which can create a path for the sub-micron Sulfuric Acid mist particle to “float” through the media uncollected.

## Fiber Bed Principles & Performance

The filter media in a fiber bed often incorporates blanket material which is uniquely designed for even gas flow distribution. The blanket material is a continuous mat material built of millions of fiberglass fibers combined together and needle punched to insure even density, distribution, and media thickness. Needled blanket can be made out of many different materials and fiber diameters.




Since the needled blanket material is manufactured separately to strict specifications, the thickness, density and fiber diameter are tightly controlled through the needling step. The tight specifications on these features of the blanket material lend the media an extremely uniform gas flow distribution and pressure drop profile across the entire surface area of the element.




Furthermore, the blanket media is a one-piece mat material, generally ¼-1" thick (5-25 mm). The fibers can be made of a variety of materials including fiberglass, Polyester, PTFE and Polypropylene, and in numerous fiber diameters. Note that the material is continuous for the full length of the candle, leaving only one vertical seam. This seam is then overlapped with the next layer of blanket media, forming a virtually seamless construction. This seamless construction insures no gas bypassing or short-circuiting through any seams, or holes.

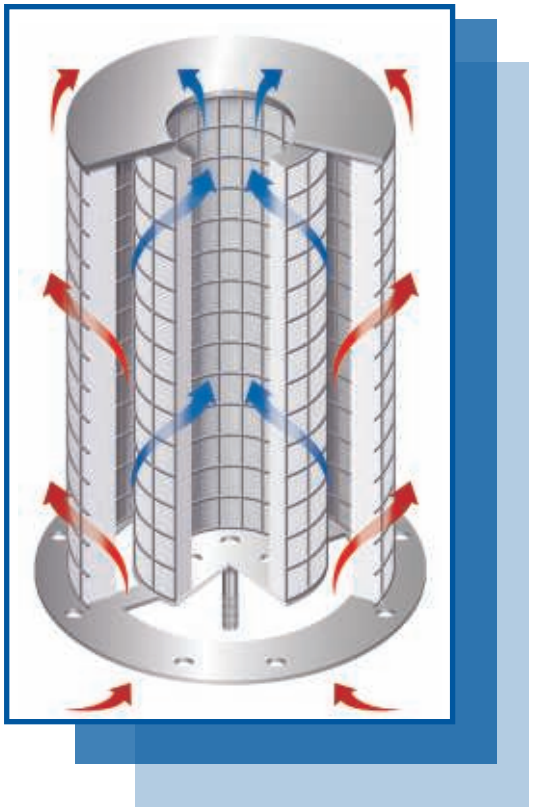
In the Graded Bed filter design the depth loading has a secondary beneficial effect in that the blanket media acts to unload the high efficiency media by first collecting the larger droplets, and facilitating the drainage of these larger droplets. This allows the second media, the high efficiency rope media, to work specifically and directly on the sub-micron mist. The lighter mist load on the rope media results in even higher collection efficiency.

The higher collection efficiency can be explained by several factors working together. The blanket media is pre-filtering and coalescing the larger droplets, thus acting to unload the rope media and boosting efficiency. Secondly, the final rope wound bed layer is wound to a very high density, allowing this layer to act as a polishing stage, working specifically on only sub-micron mist. Coalescing and drainage are improved leading to higher collection efficiency on the sub-micron droplets. This rope layer thickness and density can be adjusted to achieve the desired efficiency.

## *Replacement Filters*

CECO designs and manufactures replacement fiber bed filter elements for a wide range of processing applications to reduce and eliminate liquid mist and aerosol emissions. CECO Fiber Bed Filters are available in standard or custom-designed configurations specifically designed as replacement media solutions for existing installations. Our fiber bed coalescing filter elements offer long filter life and simplified maintenance. Both the Graded Bed and the TWIN-PAK® nested filters can be provided as replacements for existing spent or non-performing filter systems.

CECO Filters complete line of fiber bed filter mist collector systems are utilized in a wide variety of Chemical Processing applications.



## *Mist Eliminators in Sulfuric Acid Plants*

The absorption towers in Sulfuric Acid ($H_2SO_4$) plants almost always require fiber bed filters, which fall into two categories: impaction and Brownian diffusion. The process plant designer specifies what type is to be used in each tower. Generally the factors that influence the choice of fiber bed filter are:

***1) Collection/mist elimination efficiency for the expected particle size***
***2) Liquid loading at the inlet to the filters***
***3) Required outlet liquid loading limit***

The velocities in a Brownian diffusion fiber bed installation are designed to be relatively lower in order to maximize the efficiency of acid mist removal, minimize pressure drop and minimize re-entrainment of acid droplets. At velocities above 40 ft/min (20 cm/sec), diffusion collection of fine particles drops off dramatically. At the same time, pressure drop through the fiber bed filter increases.

Impaction candles and mesh pads are normally installed in drying towers where typical acid droplet sizes are greater than 1 micron. High efficiency candles are sometime used here if submicron aerosol removal is required.

Impaction filters work on the principle of inertial impaction as the primary means of particle collection. Normal bed velocities are in the range of 300 to 600 ft/min (150 to 300 cm/sec). Impaction filters can offer improved collection of particles in the 1 to 3 micron range over typical mesh pads by providing high efficiency interception collection. The collection and removal efficiencies of impaction filters are typically better than mesh pads but lower than Brownian diffusion candles.

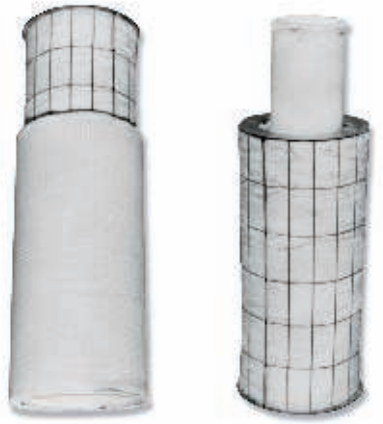
CECO Filters uses “co-knit” mesh materials in both mesh pads and impaction filters. These materials combine a fine wire mesh with a PTFE or glass fiber to provide improved impaction efficiency for fine (1-2 micron particles). The co-knit mesh provides significant particle removal efficiency enhancement in mesh pads and better pressure drop performance in impaction candles.

## Sulfonation

There are a number of chemical processes that use Sulfur Dioxide ($SO_2$) and Sulfur Trioxide ($SO_3$) to form Sulfonated organic compounds. In many cases, there are process steps that require removal of sub-micron acid mist similar to that found in Sulfuric Acid plants. These plants can also offer additional challenges due to the presence of other impurities, both organic and inorganic.

The presence of organic materials can require additional attention to filter design to ensure that oil mist re-entrainment does not occur. Soluble salts can require wash systems for the fiber bed filters. CECO engineering can work with customer engineers to develop the best wash system for each application. The presence of insoluble materials will cause filters to "blind" and pressure drop to spike. CECO can provide removable X-SERT® / N-SERT® prefilters to extend fiber bed filter life in these installations.

**X-SERT® / N-SERT®**



## Nitric Acid

CECO Filters has provided Fiber Bed Filters to the Nitric Acid Industry worldwide for more than twenty years. Nitric acid is produced by the reaction of Oxygen (provided by atmospheric air) and Ammonia to produce Nitrous gas that is then absorbed in water. The reaction takes place over a catalyst that is composed primarily of Platinum. Fiber bed filters are often used for removing sub-micron platinum particles from the product stream. The media from these elements is typically removed and reprocessed to reclaim the platinum at 60 to 180 day intervals.

Over the course of a production campaign, Platinum is lost from the catalyst and carried downstream by the nitrous gas. CECO Filters offers two styles of filter to capture the precious metal for recovery by refining facilities, thereby improving annual cash flow of the plant. CECO Filters conventional blanket wrap fiber bed filter is an economical means of recovering the platinum. Our Pleated Filter offers the same or better recovery efficiency while providing significantly more filter surface area and the ability to run longer production campaigns. Our filter designs allow plant maintenance crews to remove and replace the filter media easily on-site providing savings in shipping costs.

During the absorption of the Nitrous gas in water to yield product acid, inert Nitrogen exits the top of the absorber column often carrying nitric acid mist. If not removed, the acid mist can cause corrosion in downstream equipment. CECO Filters fiber bed diffusion filters protect the downstream equipment by removing 100% of acid mist particles larger than 3 microns and 99.9% of acid mist particles smaller than 3 micron. Acid collected by the filters can be recovered by routing it to the product storage tank. Filters in this service can provide many years of life before replacement of the filter media is required.

**Platinum Recovery Filter**

## *Ammonium Nitrate*

The exhaust from Ammonium Nitrate prilling towers, neutralizers, and evaporators can often contain sub-micron particles of Ammonium Nitrate solids and solution. These aerosols result in a high opacity plume at the exhaust stack. CECO Filters Fiber Bed Filters can eliminate this plume and thus control opacity problems.

Ammonium Nitrate solution is produced by the exothermic reaction of nitric acid and ammonia. This solution can be used as is, blended with other chemicals such as urea melt, or converted to a solid form (generally "prills"). During production of the solution and the conversion of the solution to a solid form, Ammonium Nitrate mist is generated that cannot be released to the atmosphere or to bodies of water. Conventional scrubbing alone will not capture the very fine sub-micron Ammonium Nitrate mist, thus the need for fiber bed filters to control this aerosol through the Brownian motion collection principle.

CECO Filters Fiber Bed Mist Eliminators have been successfully applied to applications in Ammonium Nitrate production plants in the US and globally. Since Fiber Bed Mist Eliminators coalesce the sub-micron mist into larger droplets that drain from the filter, the Ammonium Nitrate mist can be recovered and recycled to the process.

Media selection is a critical part of the filter design process. Proper selection yields a filter that will provide many years of service. Improper selection will yield a filter that fails prematurely incurring unnecessary downtime and cost. Operating environments of the reactor and concentrators can vary from plant to plant so there is no universally economic media that can be installed in every plant. CECO Filters has solved filter life problems by replacing commonly used polyester media with PTFE and CECO Filters proprietary ChemResist media.

## *Mist Eliminators in Chlor-Alkali Plants*

Fiber Bed filters are utilized in several aspects of the Chlorine manufacturing process. Typically chlorine is manufactured in electrolytic cells which decompose brine. From the cells Chlorine ($Cl_2$) gas and Hydrogen ($H_2$) gas are released. The Chlorine gas stream goes through a separation stage to remove entrained brine and salt particles. The final step of the separation is the wet Chlorine fiber bed filters. Their purpose is to prevent the drying tower from plugging with NaCl and to remove water from the gas stream in order to reduce Sulfuric Acid consumption in the drying tower. For this service fiber bed filters are used with high-efficiency glass fiber and cages fabricated from FRP or Titanium.

Next the gas stream goes through the drying process, also known as the dry Chlorine stream. This is accomplished by the injection of Sulfuric Acid which hygroscopically removes water from the gas stream. Sulfuric acid is thus entrained in the drying tower and the compressor (in liquid seal type processes). Fiber bed filters are installed downstream of the drying tower and/or liquid seal compressor to collect Sulfuric Acid so as to improve product purity. For this application fiber bed filters with high efficiency glass fiber media and 316L Stainless Steel cages are used.

The Hydrogen evolved from the electrolytic cell contains entrained Sodium Hydroxide (NaOH) particulate. Fiber bed filters are used for NaOH removal to purify the Hydrogen gas and to prevent corrosion of the compressor. Hydrogen removal filter media is subject to high pH caused by the caustic conditions, therefore glass fiber media is not suitable. For Hydrogen removal from the process gas stream fiber bed filters constructed of Polypropylene fiber and Stainless Steel cages are required. These filters are employed to remove NaOH mists and any other impurities, including Mercury (Hg) in the case of the older Mercury electrolytic cell processes.

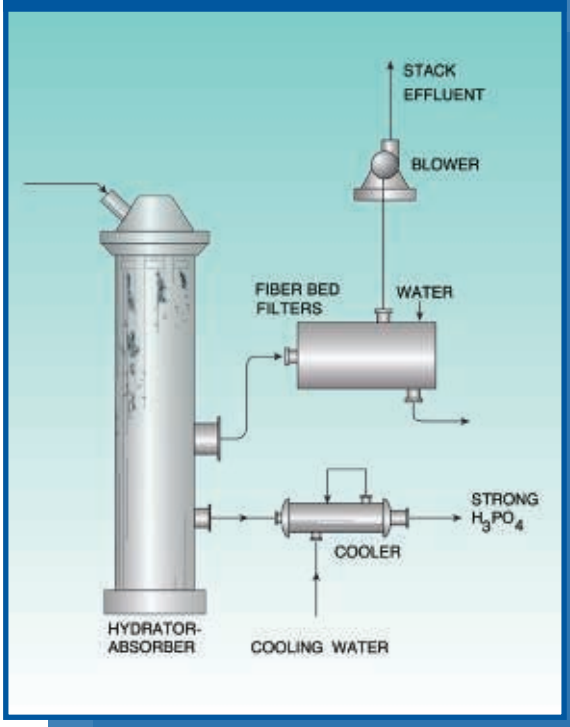
## Phosphoric Acid

Traditionally, fiber bed mist eliminators have been used to control fine mists in thermal process Phosphoric Acid. Thermal process Phosphoric Acid has been used primarily in the production of industrial and food grade Phosphates, where the ultra high purity of the thermal process Phosphoric Acid is required either for process or hygienic purposes.

Thermal process Phosphoric Acid is manufactured by burning elemental (yellow) Phosphorus to form Phosphorus Pentoxide ($P_2O_5$). The $P_2O_5$ is then absorbed into dilute Phosphoric Acid or water.

The major emission from this process is Phosphoric Acid and $P_2O_5$ mists that leave the process in the absorber exit gas. Phosphoric Acid mist concentrations can range from 0.1 to 50 mg/ft$^3$ (3.5 to 1770 mg/m$^3$) of gas with particle sizes from 1.4 to 2.6 microns. It is critical to capture this mist both for product recovery and pollution control purposes. CECO Filters has been supplying Fiber Bed Mist Eliminators for control of Phosphoric Acid mist emissions for over 30 years.

**Flow Diagram of a Thermal Process Phosphoric Acid Plant**




## Ancillary Applications in Chemical Processing Facilities

***Lube Oil Mist –*** CECO Filters Mist Collection Systems efficiently remove bearing and gear oil mists from the vent systems of rotating machinery. In addition, the recovered oil from the mist can be drained back into the turbine oil reservoir, reducing total oil consumption.

***Compressed Air –*** CECO Filters High Efficiency coalescing filter elements are designed to collect the finest liquid particles. These coalescing filter elements offer high efficiency, long filter life and low maintenance. CECO Filters coalescing filter elements are located upstream of compressed air systems equipped with a regenerative air dryer to prevent oil from saturating the dryer and reducing its efficiency.

***Polishing after Primary APC device for Opacity Control –*** Acid mists, organic mists and soluble salts leaving an Air Pollution Control train can often cause opacity problems even when the mass emissions are within regulatory limits. CECO Filters Fiber Bed Mist Eliminator Systems can provide a clear stack, just like in Sulfuric Acid absorption towers and Ammonium Nitrate prill towers.

## About CECO Filters

CECO Filters focus on unsurpassed customer service and innovative filter designs for the Chemical Processing industry has earned us a reputation as an industry leader, providing cutting edge technology solutions for the past five decades. CECO Filters designs and builds fiber bed mist eliminators and other air pollution control systems to create cleaner and safer working environments inside, and cleaner and safer emissions released outside.

## World-Wide Manufacturing, Application Engineering and Customer Service Capabilities

CECO Filters are manufactured in the United States in Telford, Pennsylvania, and in Shanghai, China. Process application engineering and technical assistance, manufacturing, field re-pack services, sales and customer service are available to serve Chemical Processing customers worldwide. The repack services are available even for filters originally supplied by others.

CECO ENVIRONMENTAL

CECO Filters is a member of the CECO Environmental family of companies, a global leader in air pollution control, energy, and fluid handling filtration technologies.

- Aarding-Flextor
- Adwest Technologies
- A.V.C. Specialists
- Buell FCC Cyclones
- Busch International
- CECO Filters
- Duall
- Effox
- Fisher-Klosterman
- Flex-Kleen
- K&B Duct & Component Parts
- Keystone Filter
- Kirk & Blum Services
- Mefiag Filtration
- Met-Pro Global Pump Solutions
- Strobic Air

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