Gas Filtration

Particle Filtration

The dramatic rise in the use of all types of high-purity gases has been driven by the process requirements for advanced device manufacturing. In order to achieve and maintain the high purities required of these gases, the selection of appropriate filters for bulk and point-of-use applications is absolutely essential.

Filter Requirements

The need for higher purity process gases used in IC manufacture has led to a rethinking of the criteria used to evaluate filter performance. A particle removal rating is not the only measure used in selecting various filter products. One must also consider the filter's potential for outgassing harmful impurities and for particle shedding.

This concern also applies to filter components and housings. Pall recognizes the importance of proper material selection, cleanliness standards, housing surface preparation, and specialized manufacturing processes with regard to product quality. Our knowledge allowed us to introduce practices that have become industry standards. All Pall Gaskleen® filter assemblies are packaged in special double bags and purged with high-purity nitrogen to prevent moisture and oxygen contamination. The outside aluminized mylar vapor barrier bag provides additional assurance of cleanliness.

Outgassing from Filters in High-Purity Gas Systems

Current demands on fluid suppliers and end users necessitate the elimination of both chemical and particulate contamination. Even if a gas is supplied at extremely high purity, the user must be able to maintain this purity and eliminate any contamination from the gas delivery and distribution systems.

Elimination of particulate contamination has been successfully accomplished through the use of high-quality filters, both at bulk and point-of-use sites. But even these filters must be chosen carefully, as variations in manufacturers' assembly techniques and handling can result in different degrees of performance between filters, even those made from similar construction materials.

Outgassing can be caused by the release of atmospheric gases, which have been absorbed onto or entrapped in the filter's materials. Exposure can occur during molding or machining of the materials, storage, cleaning, and handling. Filters made from equivalent materials have exhibited significantly different rates of outgassing due to the many chances for adsorption or entrapment of gaseous impurities by the filter.

The atmospheric gases most detrimental to semiconductor processing are water and oxygen. Both of these must be excluded to avoid disastrous effects.

Collection of Particles

Many studies have been performed to establish the sources of particulate contaminants in semiconductor-related processes. These studies have found that most particles are generated from feed gases, wafer-transport systems, pump-down and gas-phase reactions, or by-products.

Mechanism of Particle Collection

In gas filtration, the primary collection mechanisms are diffusional interception, inertial impaction and direct interception.

The influence exerted by each of these collection mechanisms is strongly dependent upon particle size and flow conditions.

Direct Interception

If the particles in a fluid stream are larger than the pore size of the filter medium, the particles will be removed as a result of direct interception. A significant proportion of particles whose diameter is smaller than the filter pore size will be removed by bridging effects and partial occlusion of pores by collected particles. The removal of particles in a gas stream by direct interception becomes more effective with increasing particle diameter.

Inertial Impaction

Particles in a fluid stream possess a certain mass and velocity, and thereby possess a certain momentum. As the fluid and entrained particles pass through a filter medium, the fluid stream will take the path of least resistance to flow and will be diverted around the pore walls. Because of their inertia, the particles will tend to continue in the previously established flow direction and impact upon the filter medium. This collection mechanism is important for particles larger than 1 µm.

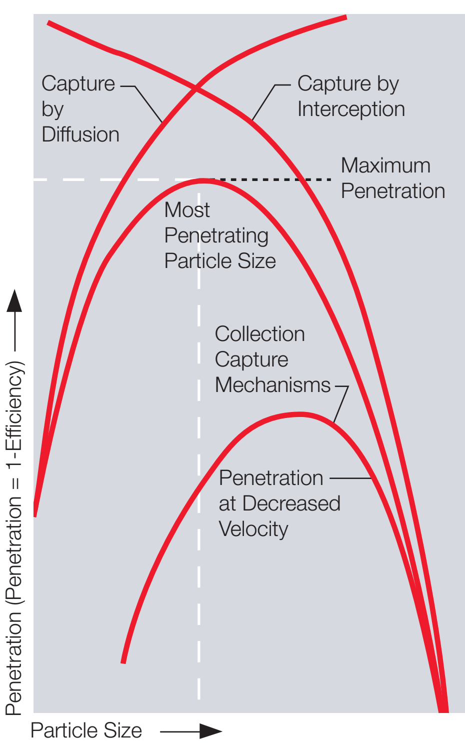
Diffusional Interception

Gas molecules are in a state of random motion. Particles smaller than 0.3 µm suspended in a gas are continually bombarded by the gas molecules, causing the particles to undergo a random walk about their path of flight (Brownian Motion). The deviation of the suspended particles from the fluid flow lines due to Brownian Motion increases the likelihood of the particles striking the filter membrane and being removed. Brownian Motion decreases with increasing particle size; diffusion is most effective at small particle sizes (0.3 µm) and becomes less important as particle sizes increase.

Most Penetrating Particle Size (MPPS)

The collection mechanisms outlined are strongly dependent upon the size of the suspended particles. The particle size dependence of the three collection mechanisms is shown in Figure 1. There exists a range at which no mechanism is dominant. In this range, known as the Most Penetrating Particle Size (MPPS), the efficiency of the filtration medium is at its minimum. This phenomenon is usually the controlling factor in rating of filters for submicron gas applications.

Figure 1
Concept of MPPS



It should be noted that the MPPS is dependent upon the operating conditions. These would include filter surface area, the gas-flow rate, differential pressure, gaseous contaminants (e.g., humidity in the case of compressed air), etc. The MPPS has been found to be in the range of 0.04 to 0.08 µm for membrane filters and 0.1 to 0.3 µm for fibrous filters. The determination of MPPS is not necessary when using Condensation Nucleus Counters (CNC) for particle detection in gas streams. The CNCs currently available detect all particles greater than 3 nm. The counts detected will include particles in the MPPS range.

Technical Issues Affecting Gas Filtration

The continuing trend of producing devices with smaller feature geometries has resulted in a much higher level of contamination control. Gases are seeing greater uses in semiconductor fabrication in both atmospheric and low-pressure applications. As a result, it has become increasingly necessary to minimize the level of ultrafine particles in a gas stream due to contamination from the gas distribution and delivery system. The efficiency of a membrane filter in gaseous service is substantially different from that of one in liquid service. Pall gas filters are typically rated at 3 nm. This value was chosen since it is the smallest particle that can be reliably measured using a condensation nucleus counter (CNC). The need for gas filters, which can be used at high temperatures, resulted in the design of high-efficiency inorganic media. These media display particulate removal capabilities equivalent to polymeric membranes.

In addition to the contamination of gas streams by ultrafine particles, there exists the possibility of chemical contamination due to outgassing of components employed in the gas distribution system. To minimize chemical contamination, gas delivery systems and their components, including filters, are being closely examined for their potential for outgassing. Outgassing is generally attributed to the release of atmospheric gases, such as moisture and oxygen, from materials used in the construction of filters.

The need for low levels of chemical contaminants in gas systems has led to the development of all-metal filters for use in critical applications, thereby eliminating polymeric materials which may outgas into the high-purity gas system. It is important to note that when a filter employed in an ultra-high-purity gas system is exposed to chemical contamination, the contaminant rapidly desorbs from the filter assembly. The all-metal filter displays excellent transparency to chemical contaminants and ensures minimum downtime when a system upset occurs. In order to achieve the desired cleanliness levels, some unwritten standards have developed in the semiconductor industry. For example, the use of electropolished 316L stainless steel is commonplace. The fine surface finishes achievable with electropolished 316L stainless steel minimize the possibility of entrapment of particles and chemicals.[1] The internal surface finish of gas filter assemblies are typically available in the 5-25 µin / 0.13–0.63 µm Ra range.

Types of Media

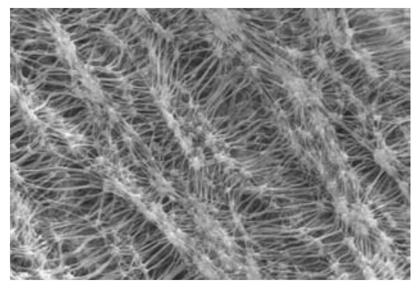
The PTFE, 316L stainless steel, nickel and ceramic media employed in Pall filters are intended for gaseous service. Refer to the photomicrographs for detailed images of the media.

Construction Techniques

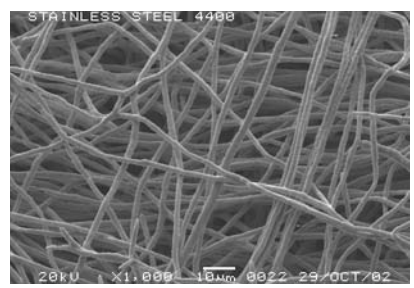
The highest degree of cleanliness and the integrity of each gas filter element and assembly is assured by rigorous quality control and stringent cleanliness procedures. Through the implementation of ultraclean manufacturing technology and cleanliness conditioning of the assemblies, end users can be assured of an in-line gas filter, which not only removes all submicron particles from the influent gas stream, but also does not add contaminants to the effluent gas.

In addition to cleanroom manufacturing and assembly, each filter is helium leak tested to a minimum of 10^{-7} atm•cm^3/s (design tested to a minimum of 10^{-9} atm•cm^3/s) and Q.C. inspected prior to shipment.[2] 100% helium leak testing assures the safety of process personnel and guards against atmospheric contamination of the process gas in an ultraclean gas system.

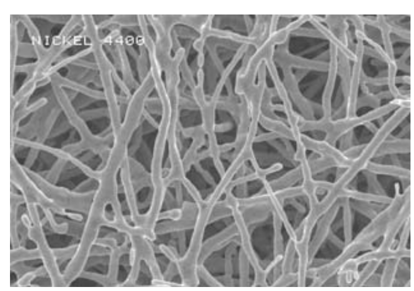
Pall Corporation utilizes automatic tungsten inert gas (TIG) welding to join 316L stainless steel components used in the manufacture of gas assemblies. Automatic TIG welding provides accurate control of all welding conditions and ensures reproducible results from weld to weld. Pall designed TIG welding does not require the use of filler metals and provides an internal surface free of crevices and oxidation. All welding processes used during assembly are designed and qualified to meet ASME standards for strength and safety. Weld strength is validated by housing burst testing, ASME standards, and examination of weld sections.



PTFE medium shown at 3000X magnification



316L Stainless steel medium shown at 1000X magnification



Nickel medium shown at 1000X magnification

1. Jensen, D., Reducing Microcontamination Generating and Entrapment Within High-Purity Gas Delivery Systems, Microcontamination, (5, 5, 1987).
2. A number of assemblies are helium leak tested to 10^{-9} atm•cm^3 / s and design tested to 2 x 10^{-11} atm•cm^3 / s.

The polishing methods applied to the wetted surfaces —bowl, fittings, etc.— of Pall gas filter assemblies produce surfaces with an extremely fine finish. Such finishes ensure that the housing surfaces will possess a minimal number of microscopic pits or crevices, which can serve as sources of particle collection and release. (For surface finish of a specific gas assembly, see the appropriate data sheet.) The electropolishing process provides a smooth, passive, continuous chromium-rich oxide layer with low concentrations of metals in their zero oxidation states, and a minimum of contaminants that can react with process gases.

Pall Corporation manufactures preconditioned filter assemblies that eliminate or greatly reduce any detrimental effects on the purity of the gas streams during installation. A preconditioning sequence has been established, which includes special integrity test methods and post-manufacturing conditioning with ultrapure gas. A preconditioned filter assembly permits the immediate use of the gas system without the need for extended purging times (dependent upon correct installation of the assembly).

Filter Test Methods for Gas Applications

Pall gas filter assemblies are subject to stringent out-of-bag particulate cleanliness testing. Lot release stipulates that each filter from a statistical sample of filters contributes no particles (larger than 0.01 µm) above the background level to a stream of clean, dry air passed through it. The particulate cleanliness of a given filter assembly is monitored using a condensation nucleus counter (CNC). The filter assembly is subjected to both steady and pulsed flow during the cleanliness test, with pulsed flow provided by automatic cycling of a solenoid valve upstream of the filter.

In the case of the Gasket-Sert™ filter, the particulate cleanliness is monitored with a laser aerosol spectrometer. The particulate cleanliness specification for the Gasket-Sert filter is ≤1 particle / (m^3 or ft^3) ≤1 µm. Gas assemblies are rated for absolute retention of particles down to 3 nm (0.4 µm for the Gasket-Sert filter) in size. Filter assemblies are challenged with an aerosolized polydispersed NaCl solution. Downstream counts are determined by isokinetically sampling a portion of the gas stream into the CNC or laser spectrometer. Particle-size distribution of the aerosol challenge material includes the most penetrating particle size (MPPS) for the range of flows for which the filter is recommended (see Mechanism of Particle Collection, Figure 1).

Gas filter assemblies are helium leak tested to ensure the integrity of welds or other connections on an assembly. Prior to any preconditioning steps that are part of manufacturing, the assembly is tested with ultra-high-purity helium leak detection equipment and a tracer probe. Gas assemblies are helium leak tested to 10^{-7} or 10^{-9} atm•cm^3/s, depending on the product specification. Pall Corporation utilizes high-quality surface finish measuring equipment to evaluate the surface roughness of wetted surfaces requiring extremely smooth surfaces. The surface finish is evaluated with stylus measuring instruments and scanning electron microscopy (SEM). The stylus is typically drawn across a representative area of a section of an assembly to determine surface parameters. The surface finishes attained are ≤25 µin / 0.63 µm Ra and for particular assemblies ≤5 µin / 0.13 µm Ra. The process used to electropolish the housings of Pall gas assemblies is qualified by analytical techniques: Auger electron spectroscopy (AES), and electron spectroscopy for chemical analysis (ESCA).

Pall preconditioned gas filter assemblies are 100% tested for moisture and total hydrocarbon (THC) cleanliness by monitoring filter effluent during manufacturing preconditioning. The moisture cleanliness levels are monitored with a moisture analyzer (electrolytic cell type). The effluent of the filter assembly must contribute <10 ppb moisture concentration above the influent test gas. The THC cleanliness levels are monitored in manufacturing with a THC analyzer and must contribute <10 ppb.

This process has been validated with a flame ionization detector with a detection limit of <10 ppb.
To verify dryness and residual THC after packing (double bagging under high-purity nitrogen with aluminized mylar and polyethylene bags), filters are statistically sampled and analyzed for moisture and THC levels.

Gas Filter Study

Comparison of 316L Stainless Steel and Nickel Media in Corrosive Service
The choice of components for use in corrosive gas service will determine the extent of corrosion and affect the quality of the gas delivered to the process tool.

A series of evaluations were performed to compare the corrosion resistance of a gas filter assembly employing nickel medium (GLFN1100VMM4) with one employing 316L stainless steel medium (GLFF1100VMM4). The all-metal assemblies employed in the study are constructed of an EP 316L stainless steel housing and a medium pack (nickel or 316L stainless steel) of sintered metal fiber of a specified diameter. The housing of the assemblies has an internal surface finish of ≤7 µin / 0.18 µm Ra and chromium enriched surface layer. The assemblies were subjected to an initial particle cleanliness test, exposed to HCl on a specific exposure cycle, tested for particle generation, and then examined for internal corrosion.

The initial particle cleanliness test, based on Sematech Semaspec #93021511A-Std, confirmed that there was no particle contribution above background (<1 particle / m^3 or ft^3). The filters were then exposed to the sequence in Table 3 once per hour for six hours.

After the completion of the sixth hour, the test filter assembly was held in static HCl for 18 hours. This exposure cycle was repeated eight times. The moisture content of the HCl was maintained at < 100 ppb using an HCl gas purifier. The test filters were subjected to a 2-hour dry nitrogen purge following completion of the eight day HCl exposure.

Table 3. Exposure Sequence for Test Components

Step	Time (mins)	Condition
1	5	Flow dry N_2, 0.5 slpm
2	10	Flow wet N_2, (100 ppm H_20), 0.5 slpm
3	5	Flow dry HCl, 0.5 slpm
4	40	Stagnant HCl, no flow

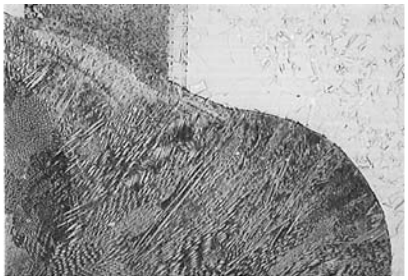
The filter assemblies were then retested for particle cleanliness. The particles detected downstream were immediately within background levels, indicating that no particle corrosion by-products were generated during the HCl exposure.

The exposed samples were then sectioned and subjected to microscopic inspection to determine changes in surface morphology. The assemblies exhibited a fine surface finish (≤7µin / 0.18 µm Ra), suggesting that the internal surfaces of the filter assemblies were not subjected to corrosion. The weld regions of the assemblies were also evaluated (Figure 3). These revealed no evidence of corrosion. The media packs were evaluated based on their pre and post exposure diameters and SEM photomicrographs (Figure 4). The diameters of the fibers in the filter packs were identical pre-and post-exposure. The photomicrographs revealed some contamination (scaling), but no degradation of the sintered fibers.

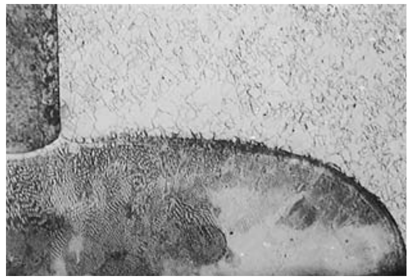
The point-of-use all-metal filter assemblies with 316L stainless steel medium and nickel medium evaluated in HCl gas revealed no evidence of the generation of particles due to corrosion. The particle cleanliness of the assemblies after exposure to HCl gas was observed to be within background levels, even under dynamic and impact test conditions. In addition, the assemblies displayed a high surface finish and no evidence of corrosion or degradation of the media packs.

These observations indicate that the 316L stainless steel medium pack and the nickel medium pack are corrosion resistant under normal service conditions experienced in a semiconductor corrosive gas distribution system. In the case of reactive specialty gases, such as arsine, phosphine and silane, however, consideration must be given to the catalytic behavior of various metal surfaces.

Figure 3

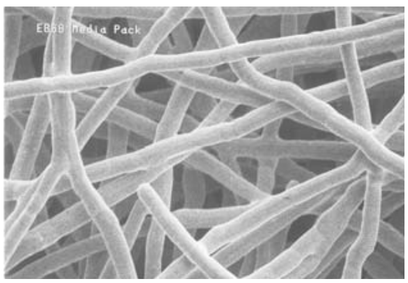


Weld region stainless steel filter (GLFF1100VMM4)

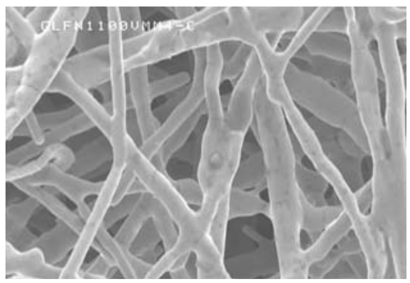


Weld region nickel filter (GLFN1100VMM4)

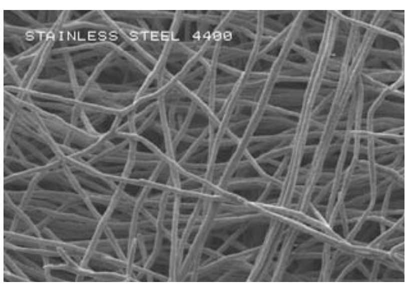
Figure 4



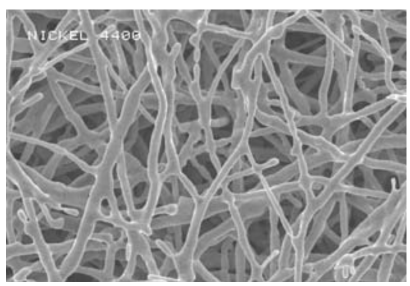
316 Stainless steel fibers–control



Nickel fibers–control



316 Stainless steel fibers–test components



Nickel fibers–test component

New Gas Filtration Trends

Top Mount Components

The Integrated Gas Delivery System is the newest design to incorporate components in gas delivery systems. In this design, the components are integrated on the surface mount substrate, offering many advantages in reduced space requirements, equipment downtime, and cost.

Pall's Top Mount Filter Assemblies are ideally suited for Integrated Gas Delivery Systems, providing easy access and change-out upon the mounted substrate. The filters are designed for >3 nm filtration of semiconductor grade gases and are available in a variety of materials, flow rates, and interface connections. The assemblies are available in 316L stainless steel, nickel, and PTFE media up to 100 slpm. The assemblies are also available in a variety of interfaces including C-seal and W-seal.

Diffusers

Gas diffusers are ideally suited for vent applications on load lock interfaces or other vacuum chambers where large volumes of gas are flowing through a small orifice in a short amount of time. Pall's ChamberKleen™ diffuser combines a stainless steel filter and a unique diffuser membrane that allows flow in 360 degrees. This combination allows large volumes of gas to flow in a uniform manner, limiting the disturbance of particles in the chamber. Consequently, fast vent times can be achieved with little particle disturbance contributing to a high wafer throughput and overall equipment efficiency.

Compatability Guide

The compatibility data presented in this chart are for general guidance only. Because so many factors can affect the chemical resistance of a given product, you should pretest under your own operating conditions, observing applicable safety practices such as those given on the Material Safety Data Sheet for each chemical. If any doubt exists about specific applications, please contact Pall Corporation.

Filtration Products Compatibility Guide

- E Excellent
- G Good at Ambient Temperatures
- LR Limited Recommendation
- NR Not Recommended

Please contact Pall Microelectronics for specific recommendations.

	POU Filtration						Bulk		O-Rings			
Gas	Gaskleen®	Gaskleen V	Membralox®	Mini Gaskleen / PFA Gaskleen	316L Ultramet-L®	Ultramet-L Nickel Media	Emflon®	Emflon PF	Viton[1] A	Silicone	EPR	FEP/Viton
Air (CDA System)	E	E	E	E	E	E	E	E	E	E	E	E
Ammonia (NH_3)	NR	E	E	NR	E	G	G	E	NR	NR	G	NR
Argon (Ar)	E	E	E	E	E	E	E	E	E	E	E	E
Arsine (AsH_3)	G	E	E	E	E	G	G	E	G	G	G	E
Boron Trichloride (BCl_3)	LR	E	E	E	E	G	G	E	LR	NR	NR	E
Boron Trifluoride (BF_3)	NR	E	NR	E	E	G	NR	E	NR	NR	NR	E
Carbon Monoxide (CO)	E	E	E	E	E	NR	E	E	E	E	E	E
Carbon Dioxide (CO_2)	E	E	E	E	E	E	E	E	E	E	E	E
Carbon Tetrachloride (CCl_4)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Carbon Tetrafluoride (CF_4)	NR	E	LR	E	E	G	NR	E	NR	NR	NR	E
Chlorine (Cl_2)	NR	E	E	E	E	G	NR	E	NR	NR	NR	E
Diborane (B_2H_6)	G	E	E	E	E	G	E	G	G	G	G	E
Dichlorosilane (SiH_2Cl_2)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Hexafluoroethane (C_2F_6)	NR	E	LR	E	E	G	NR	E	NR	NR	NR	E
Hydrogen (H_2)	G	E	E	E	E	E	G	E	G	NR	G	E
Hydrogen Bromide (HBr)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Hydrogen Chloride (HCl)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Hydrogen Fluoride (HF)	NR	E	NR	E	E	G	NR	E	NR	NR	NR	E
Nitrogen (N_2)	E	E	E	E	E	E	E	E	E	E	E	E
Nitrogen Trifluoride (NF_3)	NR	E	NR	E	E	G	G	E	NR	NR	NR	E
Nitrous Oxide (N_2O)	LR	E	E	E	E	E	LR	E	G	G	E	E

Filtration Products Compatibility Guide, cont'd.

E Excellent
G Good at Ambient Temperatures
LR Limited Recommendation
NR Not Recommended

Please contact Pall Microelectronics for specific recommendations.

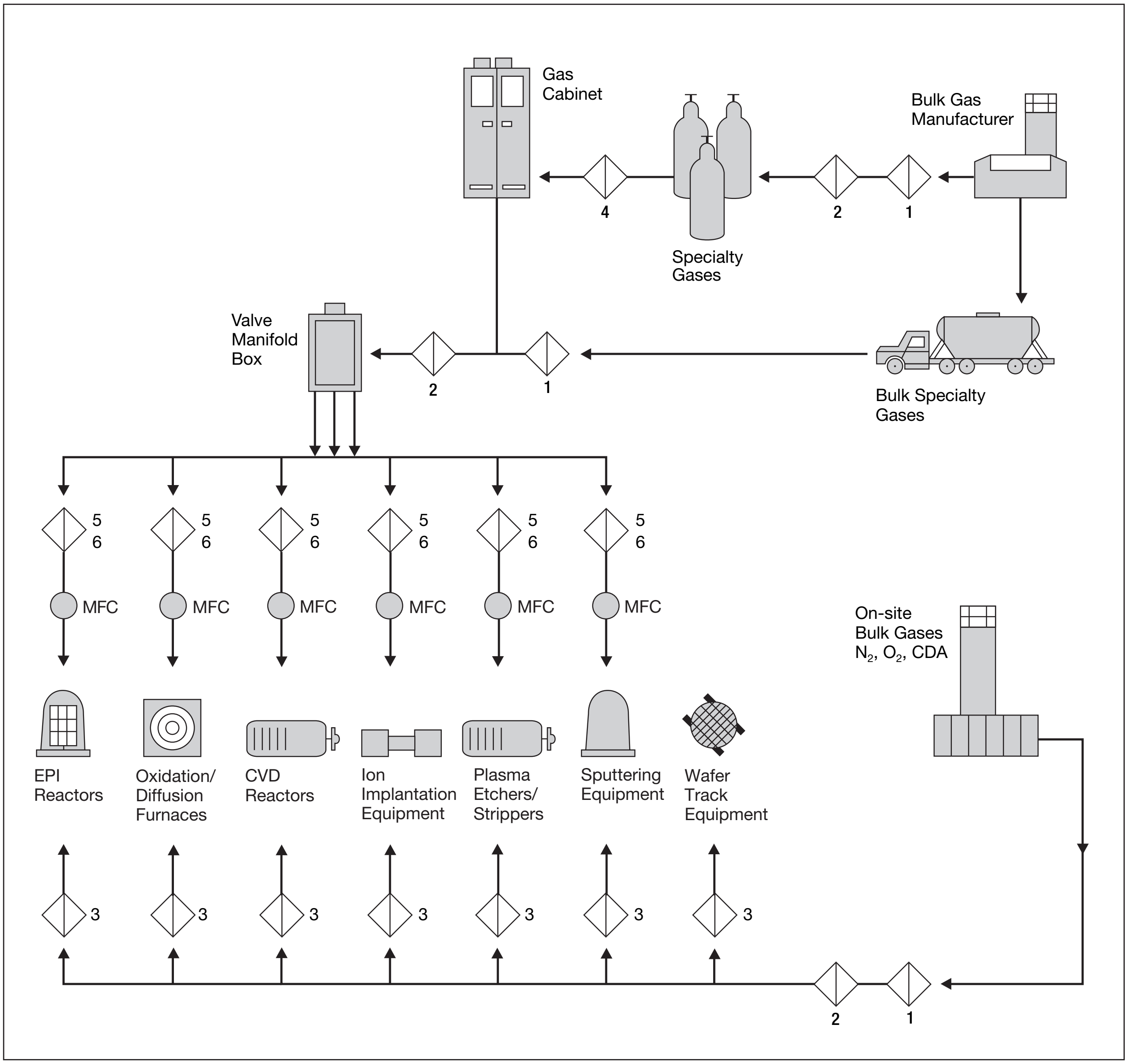
	POU Filtration						Bulk		O-Rings			
Gas, cont'd	Gaskleen®	Gaskleen V	Membralox®	Mini Gaskleen / PFA Gaskleen	316L Ultramet-L®	Ultramet-L Nickel Media	Emflon®	Emflon PF	Viton[1] A	Silicone	EPA	FEP/Viton
Oxygen (O_2)	NR	E	E	E	E	G	NR	E	NR	NR	NR	E
Ozone (O_3)	NR	E	E	E	NR	NR	NR	E	NR	NR	NR	E
Phosphine (PH_3)	G	E	E	E	E	G	G	E	G	G	G	E
Phosphorous Pentachloride (PCl_5)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Phosphorous Pentafluoride (PF_5)	NR	E	NR	E	E	G	NR	E	NR	NR	NR	E
Silane (SiH_4)	G	E	E	E	E	G	G	E	G	G	G	E
Silicon Tetrachloride ($SiCl_4$)	LR	E	E	E	E	G	LR	E	LR	NR	NR	E
Stibine (SbH_3)	G	E	E	E	E	G	G	E	G	G	G	E
Tetraethyl Orthosilicate (TEOS)	G	E	E	E	E	G	G	E	G	G	G	E
Trimethyl Borane ($(CH_3)_3B$)	G	E	E	E	E	G	G	E	G	G	G	E
Trimethyl Phosphate ($(CH_3)_3PO$,	G	E	E	E	E	G	G	E	G	G	G	E
Tungsten Hexafluoride (WF_6)	NR	E	NR	E	E	G	NR	E	NR	NR	NR	E

Note: 316L and nickel media Ultramet-L Gaskleen filter assemblies are rated G in halogenated gases if **not anhydrous.** Anhydrous gases are defined as gases with moisture levels < 1ppm. Nickel media Ultramet-L Gaskleen filter assembly is also rated G in reactive gases at ambient temperatures.

[1] Viton is a trademark of DuPont Dow Elastomers

Unit conversion: 100 kilopascals = 1 bar

Gas Flow Schematic



General Gas Filter Recommendations

Application	Diagram Number	Filter Type	Description of Application
Bulk Non-Toxic	**1**	Accusep® Sealed-in-Line Series filter assembly	Nickel filter media with 316L stainless steel housing.
		High-Flow Ultramet-L® filter assembly	All 316L stainless steel filtration for bulk applications.
		Gaskleen Sealed-in-Line filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly.
		Emflon® PF filter	PTFE media / PFA hardware cartridge for use in oxygenated gas service.
		Emflon filter	PTFE media / Polypropylene hardware cartridge for use in non-oxygenated gas service.
		High-Flow Emflon filter	PTFE media / Polypropylene hardware cartridge for use in very high flow rate, non-oxygenated gas service.
		Membralox® Series filter assemblies	Ceramic filter medium and 316L stainless steel housing assembly.
Chase / Core	**2**	Emflon filter	PTFE media / Polypropylene hardware cartridge for use in non-oxygenated gas service.
		Maxi Gaskleen 8202 / 9202 Series filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly for flow rates up to 1,500 slpm.
		Gaskleen V Series filter assemblies	Sealed polymeric cartridge and 316L stainless steel housing assembly for flow rates up to 1,200 slpm.
		Ultramet-L 6600 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel filtration up to 320 slpm.
		Ultramet-L 5500 Series filter assembly	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 150 slpm.
		Ultramet-L 4281 / 4581 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 75 slpm.
		Membralox® Series filter assemblies	Ceramic filter medium and 316L stainless steel housing for flows up to 1,000 slpm.
Process Equipment Non-Toxic	**3**	PSP Gasket-Sert™ filter	Protects major components of gas panels, zero displacement.
		Ultramet-L Nickel 3600 filter assembly	Nickel media with stainless housing for flows up to 100 slpm.
		Gaskleen V Series filter assemblies	Sealed polymeric cartridge and 316L stainless steel housing assembly for flow rates up to 1,200 slpm.
		Hi-Flow Mini Gaskleen filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly for flow rates up to 120 slpm.
		Membralox® Series filter assemblies	Ceramic filter medium and 316L stainless steel housing for flows up to 160 slpm.

General Gas Filter Recommendation continued

Application	Diagram Number	Filter Type	Description of Application
Specialty Gas Cabinets	**4**	PSP Gasket-Sert™ filter	Protects major components of gas panels, zero displacement.
		Ultramet-L Nickel 3600 filter assembly	Nickel media with stainless housing for flows up to 100 slpm.
		Ultramet-L 4281 / 4581 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 75 slpm.
		Hi-Flow Mini Gaskleen filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly for flow rates up to 120 slpm.
		Membralox Series filter assembly	Ceramic filter medium and 316L stainless steel housing for flows up to 80 slpm.
Gas Panels / Sticks	**5**	Top Mount filter assembly	Filtration for integrated gas delivery system
		Ultramet-L 4281 / 4581 Series filter assembly	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 75 slpm.
		Hi-Flow Mini Gaskleen filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly for flows up to 120 slpm.
		Ultramet-L 1100 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 15 slpm.
		Membralox Series filter assemblies	Ceramic filter medium and 316L stainless steel housing for flows up to 80 slpm.
Equipment	**6**	Top Mount filter assembly	Filtration for integrated gas delivery systems.
		ChamberKleen™ diffuser filter	Reduces particle disturbance during venting of chambers.
		Ultramet-L 4281 / 4581 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 75 slpm.
		Hi-Flow Mini Gaskleen filter assembly	Sealed polymeric cartridge and 316L stainless steel housing assembly for flows up to 120 slpm.
		Ultramet-L 1100 Series filter assemblies	Nickel or stainless steel filter media with 316L stainless steel housing for flows up to 15 slpm.
		Membralox Series filter assemblies	Ceramic filter medium and 316L stainless steel housing for flows up to 80 slpm.

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