Appendices

Filtration Simplified

Basic Filtration Concepts and Terms

Selecting a filter with the appropriate properties can help you achieve accurate results and reach discovery faster. But with so many types of filters to choose from, how can you be sure you're making the right choice? Whatman has assembled this compilation of basic filtration concepts and terms to clarify the various options available to you and speed the process of selection.

Airborne Particle Retention

Retention mechanisms for removing particulates from air or gas enable much higher efficiencies to be realized than those applicable to liquids. Efficiencies for air filtration are normally expressed as percent penetration or retention for a stated airborne particle size. In the United States, the Dioctyl Phthalate (DOP) test is commonly used wherein the filter is challenged with an aerosol containing 0.3 µm particles.

Ash Content

Determined by ignition of the cellulose filter at 900°C in air. Ash content is essential in gravimetric applications and also a useful measure of the level of general purity.

Chemical Compatibility

It is very important to ensure that the pore structure of the filter media will not be impaired by exposure to certain chemicals. In addition, exposure to these chemicals should not cause the filter to shed fibers or particles, or add extractibles. Length of time exposure, temperature, concentration and applied pressure can all effect compatibility. Whatman has provided chemical compatibility charts to aid your membrane selection (See page 181).

Depth Filters

Depth filters are usually characterized as those which retain particles on the surface and within the filter matrix. All conventional fibrous filters (whether manufactured from cellulose, borosilicate glass microfiber or other fibrous material) are depth filters and are normally characterized by exhibiting good loading capacity.

Herzberg Method

Whatman quantifies liquid flow rate for its range of filters by using a Herzberg flow rate tester. Prefiltered deaerated water is applied to the test filter (effective area 10 cm^2) at a constant hydrostatic head (10 cm). The rate of the flow is measured in seconds per 100 mL. Flow rate can also be measured by the modified ASTM method which uses a quadrant folded filter held in a wire loop. It is not considered to be as reliable or consistent as the Herzberg test.

Hydrophilic

Because hydrophilic filters possess an affinity for water and can be wetted with virtually any liquid, they are typically used for aqueous solutions.

Hydrophobic

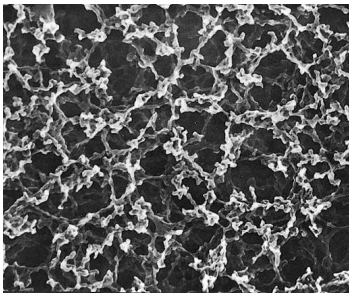
These types of filters repel water, and are thus best suited for venting or gas filtration applications.

Liquid Flow Rate

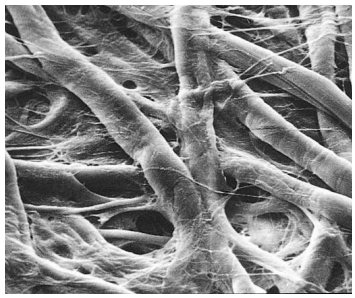
Under practical filtration conditions, the liquid flow rate will depend on a number of factors, many of which will be specific to the solid/liquid system being filtered. In order to compare filter performances, a standardized set of conditions is required which will characterize liquid flow rate for a given filter without the complicating secondary effects derived from the presence of particulates. Liquid flow rate is tested with prefiltered, deaerated water using a flat filter subjected to a constant hydrostatic head. Test methods based on quadrant folded filters are considered unreliable.

Loading Capacity

This relates to the ability of a filter to load particulates into the fibrous matrix while maintaining a practical filtration

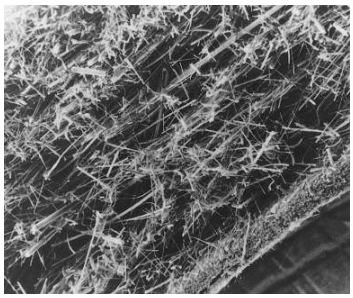


Membrane filters allow the efficient retention of submicron particulates and organisms.



Whatman cellulose filter papers exhibit particle retention levels down to 2.5 µm.

Glass microfiber filters are manufactured by Whatman from 100% borosilicate glass.



Multigrade GMF 150 combines two filters in one for fast, effective multilayered filtration.

speed and a workable pressure differential across the filter. In general, glass microfiber filters have a high loading capacity when compared with cellulose filters of the same retention rating and thickness. Membranes are inherently low in loading capacity. "Choking life" is a measure of loading capacity.

Particle Retention (liquid)

In a filtration process, the particle retention efficiency of a depth-type filter is expressed in terms of the particle size (in µm) at which a retention level of 98% of the total number of particles initially challenging the filter is obtained. It is customary to quote the retention levels at 98% efficiency to allow for secondary filtration effects. All Whatman depth filter grades have a published nominal retention rating determined on this basis.

Pore Size

The pore size, usually stated in micrometers (mm), of Whatman filter media is defined by the diameter of particles retained by the filter matrix. Pore size ratings, which can be either nominal or absolute, refer to the size of organisms or particles retained by the filter media.

Prefilters

Prefilters are traditionally depth filters placed upstream from a membrane filter to significantly reduce the particulate loading in the system and thereby allow the membrane to operate efficiently at a light particulate loading.

Screen or Surface Filters

Membrane filters are generally described as screen filters because particles are almost entirely trapped on the filter surface. The narrow effective pore size distribution of Whatman membrane filters is one of their major features.

Filter Types and Filter Holders

Filter Papers

Whatman qualitative and quantitative filter papers are, with few exceptions, manufactured from high quality cotton linters which have been treated to achieve a minimum alpha cellulose content of 98%.

These cellulose filter papers are used for general filtration and exhibit particle retention levels down to 2.5 µm. There is a wide choice of retention/flow rate combinations to match numerous laboratory applications.

The different groups of filter paper types offer increasing degrees of purity, hardness and chemical resistance. Whatman quantitative filter papers have extremely high purity for analytical and gravimetric work.

Glass Microfiber Filters (GMF)

The unique properties of borosilicate glass microfibers enable Whatman to manufacture filters with retention levels extended into the submicron range. These depth filters combine fast flow rate with high loading capacity and retention of very fine particulates. Due to the high void volume exhibited by glass microfiber filters, the choking life is considerably extended beyond the life of a cellulose filter of similar retention.

Whatman glass microfiber filters are manufactured from 100% borosilicate glass and are completely binder-free. Binder-free glass microfiber filters will withstand temperatures up to 550°C and can therefore be used in gravimetric analysis where ignition is involved.

Membrane Filters

Unlike cellulose and glass microfiber depth filters, membrane filters are conventionally classified as surface filters because the filter matrix acts as a screen and retains particulates almost entirely on the smooth membrane surface. The retention levels for these filters extend down to 0.02 µm and allow the efficient retention of submicron particulates and organisms. Water microbiology and air pollution monitoring are major applications of membranes.

Prefilters

The life of a membrane filter can be extended many times by placing a prefilter upstream of the membrane. The total particulate load challenging the membrane is considerably reduced thus allowing the membrane to operate efficiently.

Standard Circle Funnel Volumes

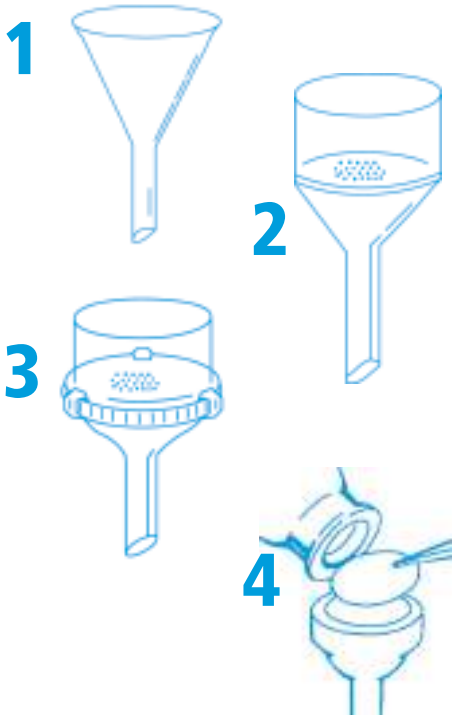
The maximum practical volume of the most popular circle sizes (quadrant folded) is given in the following charts. Membrane and glass microfiber filters are used flat.

Diameter (cm)	Volume (mL)
9	15
11	20
12.5	35
15	75
18.5	135
24	300

Types of Filter Holders

A filter matrix requires a suitable support structure to enable it to be used for the filtration of liquids or gases. One of the simplest forms of holder is the conical glass filter funnel into which a quadrant folded or fluted filter paper is placed (1, see next page). Some applications require additional motivating force for the solid particulate/liquid separation to occur (i.e., vacuum assisted filtration). This type of filtration can be carried out in a

one-piece Buchner style funnel (2) where the filter is used flat on a perforated base sealed into the funnel. Due to the difficulties encountered in cleaning this type of funnel, the demountable 3-piece funnel was developed (3). The Whatman 3-Piece Filter Funnel is fully demountable and enables the filter paper to be securely clamped between the support plate and filter reservoir flange. Membrane holders (4) incorporate either sealed-in sintered glass or removable stainless steel mesh supports for the membrane. Syringe and in-line filters are also available. Large diameter membranes are typically used in pressure holders.



Selecting the Right Filter

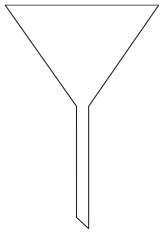
The selection of a laboratory filter depends on the conditions and objectives of the experiment or analytical procedure. The three most important characteristics of any laboratory filter are:

- Particle retention efficiency
- Fluid flow rate through the filter
- Loading capacity

In addition, according to the particular application, other important characteristics may require examination. For instance, wet strength, chemical resistance, purity and ash level may assume equal importance under certain circumstances.

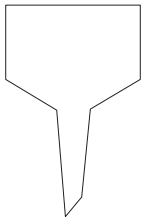
Standard 58° or 60° Funnels Glass/Polyethylene

Funnel Diameter (mm)	Filter Paper Size (cm)
35	5.5
45	7.0
55	9.0
65	11.0
75	12.5
90	15.0
100	18.5
160	24.0
180	32.0
220	40.0
260	50.0



Buchner Funnel Filter Selection Table

Coors Catalog Number	Diameter (mm)	Perforated Area (mm)	Filter Paper Size (mm)
60239	43	32	42.5
60240	63	42	55
60242	83	60	75
60243	100	77	90
60244	114	95	110
60245	126	105	125
60246	151	135	150
60247	186	160	185
60248	253	213	240



Typical Particle Sizes	
Gelatinous Precipitates	**µm**
Metal hydroxides	25–40
Precipitated silica	25–40
Crystalline Precipitates	
Ammonium phosphomolybdate	20
Calcium oxatate	15
Lead sulphate	10
Barium sulphate (hot ppt.)	8
Barium sulphate (cold ppt.)	3
Blood Cells	
Platelets	2–3
Erythrocytes (average)	7.0
Polymorphs	8–12
Small lymphocytes	7–10
Large lymphocytes	12–15
Monocytes	16–22
Bacteria*	
Cocci	0.5
Bacilli	1.0 x (1.0–1.0)
Serratia marcescens	0.5 x (0.5–1.0)
Pneumococcus	1.0
Bacillius tuberculosis	0.3 x (2.5–3.5)
Amoeba	12-30
E.coli	0.5 x (1.0–3.0)
Smallest bacteria	0.22
Other Microorganisms, etc.	
Yeast cells	2.0–8.0
Tobacco smoke	0.5
Colloids	0.06–0.30
Rye grass pollen	34
Ragweed pollen	20
Puffball spores	3.3

* Where bacteria are rod-shaped, range of lengths is given in brackets.