Public Works and Government Services Canada
Mechanical and Maintenance Engineering
Real Property Branch

MD 16001 — 2007

Air Filters for HVAC Systems

Guidelines for Building Owners, Design Professionals, and Maintenance Personnel

Public Works and Government Services Canada
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PWGSC

Mechanical Design Guidelines

MD 16001 — 2008

Air Filters for HVAC Systems

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Mechanical and Maintenance Engineering

Professional and Technical Programs
Architectural and Engineering Resources Directorate
Real Property Branch
Public Works and Government Services Canada
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Public Information

Public Works and Government Services, Canada is pleased to present the revised Mechanical Design Guideline MD 16001 - 2007 "*Air Filters for HVAC Systems*".

Air Filtration has become very important in recent times as an essential tool for maintaining adequate indoor air quality in buildings as well as to provide a first line of defence against airborne diseases. Air filtration is also required for protection of HVAC equipment.

The objective of this document is to provide general guidance for the design of air filtration systems based on current codes, standards and guidelines. It is intended for application to both new and existing buildings including the retrofit of existing buildings. It does not, however, apply to leased buildings.

The document describes various filter types, filter selection, methods of testing filters and filter rating methods. It also provides a clear explanation of the various rating parameters such as "dust spot efficiency", "arrestance", and MERV ratings for air filters.

The document has been developed by the Mechanical and Maintenance Engineering group, AER, PTP, NCA, in consultation with specialists and engineering professionals from throughout the regions.

A previous version of this guideline was published in the 1980's but it requires major revisions due to the evolution of filtration technology and filter rating

Travaux publics et Services gouvernementaux Canada a le plaisir de vous présenter les Lignes directrices d'ingénierie mécanique IM 16001 – 2007 « *Filtres à air pour les systèmes de CVCA* ».

La filtration de l'air a récemment pris une importance considérable en tant qu'outil essentiel pour le maintien d'une qualité d'air intérieur appropriée dans les immeubles, et elle joue un rôle de premier plan dans la protection contre les maladies qui se propagent dans l'air. En outre, elle constitue une exigence essentielle dans la protection de l'équipement de CVCA.

Le présent document a pour objet d'offrir des conseils généraux sur la conception des systèmes de filtration de l'air en tenant compte des codes, des normes et des lignes directrices en vigueur. Il s'applique aux immeubles nouveaux et existants ainsi qu'aux projets de modernisation des immeubles existants. Toutefois, il ne s'applique pas aux immeubles loués à bail.

Les présentes lignes directrices décrivent divers types de filtres ainsi que les méthodes d'essai, de sélection et de classement des filtres. Elles expliquent aussi clairement les divers paramètres de classement, notamment le degré de dépoussiérage de l'air, le pouvoir de captation et les valeurs d'efficacité (MERV).

Le présent document a été élaboré par le groupe du Génie mécanique et d'entretien, RAG, PPT du SCN avec la collaboration de spécialistes et d'ingénieurs de l'ensemble des régions.

methods. There has also been a shift in the purpose of using air filters. Initially, air filters were used largely for protection of mechanical equipment, but over the years, the emphasis has shifted towards health, safety and security concerns.

It is important that clients, property managers, engineers and maintenance personnel be familiar with the contents of this document, so that they can apply the guidelines in a consistent manner for federal projects throughout Canada.

This document is available in either hard copy or electronic format from the PWGSC Documentation Center at doc.centre@pwgsc.gc.ca.

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Une première version de ces lignes directrices a été publiée dans les années 80, mais elle est devenue désuète en raison de l'évolution de la technologie de filtration et des méthodes de classement des filtres. L'utilité des filtres à air a aussi changé. Au départ, ils servaient surtout pour la protection des installations techniques, mais avec le temps, ils ont plutôt commencé à répondre aux questions de santé, de sécurité et de sûreté.

Il est important que les clients, les gestionnaires immobiliers, les ingénieurs et le personnel d'entretien connaissent bien le contenu de ces lignes directrices afin de pouvoir les appliquer d'une façon uniforme dans les projets de TPSGC partout au Canada.

Vous trouverez ce document en copie papier ou en version électronique au Centre de documentation de TPSGC à l'adresse doc.centre@tpsgc.gc.ca.

Pour obtenir plus de renseignements concernant les présentes lignes directrices, veuillez communiquer avec :

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Introduction

General

This document has been developed by the Mechanical and Maintenance Engineering group of Professional and Technical Programs, Architectural and Engineering Resources Directorate, Real Property Branch, Public Works and Government Services Canada.

Feedback

Corrections, recommendations, suggestions for modifications or additional information and instructions that will improve this document are invited. For this purpose the attached form entitled "Request for change to this manual" may be used and mailed or faxed to the address shown. E-mail or other forms of electronic transmission may also be used for this purpose.

Conflicts

Any area of conflict between this document and the Project Brief/RFP shall be brought to the attention of the Project Manager as soon as it is noted.

MD16001 - 2007 Air Filters for HVAC Systems REQUEST FOR CHANGES	
Edward Durand, P Eng. National Manager Mechanical and Maintenance Eng. Group Professional and Technical Programs Architectural and Engineering Resources Dir. Real Property Branch Public Works and Government Services Canada Portage III 9A1 - 11 Laurier Street Gatineau, Quebec K1A 0S5 Tel: 819-956-2490 FAX: 819-956-2720 E-mail: edward.durand@pwgsc.gc.ca	**Paul Sra, P Eng.** Supervisor, Senior Mechanical Engineer Mechanical and Maintenance Eng. Group Professional and Technical Programs Architectural and Engineering Resources Dir. Real Property Branch Public Works and Government Services Canada Portage III 9A1 - 11 Laurier Street Gatineau, Quebec K1A 0S5 Tel: 819-956-3972. FAX: 819-956-2720 E-mail: paul.sra@pwgsc.gc.ca
Type of change suggested:	
☐ Correction of information ☐ Deletion of information ☐ Addition of Information	
Details of suggested changes:	
If necessary, photocopy relevant page(s) of this manual and attach to this sheet. Page: Chapter: Paragraph no.:	
Details of suggested changes:	

(Use additional sheets if necessary)

Signature: _________________ Phone No:._________________ Date: ________________

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Chapter 1 Introduction

1.1 Purpose

This document has been developed to provide general guidance for the use of air filters for HVAC systems, as used in PWGSC buildings. It is intended for use in new and existing buildings, and for retrofits to existing buildings.

This document should not be construed as a rigid set of standards to be followed at the expense of innovative design, but rather, as a benchmark of design excellence against which decisions may be compared.

1.2 Scope

The target audience for this document is property managers, engineers, designers, installers, maintenance personnel, and, property owners.

This document supports the Project Brief and/or the RFP, if available, as these are the prime reference documents for each project.

1.3 History of this Document

The document was first developed by the Building Consulting Section of the Mechanical Engineering division at Public Works Canada, and published in March 1987 under the title "MD 15600-5 Standards and Guidelines HVAC: Air Filters". In view of the rapid growth of the air filtration industry, this document requires updates.

Earliest applications of air filtration in HVAC systems were primarily for the protection of mechanical equipment, such as cooling/heating coils exposed to dust in the airstream. This type of application required very basic filtration simply to screen out the larger particles.

Growing indoor air quality concerns lead to the use of air filters for maintaining occupant comfort and health, by filtering out particulates, bacteria and spores. In very recent times, the threat of bio-terrorism has led to the need for even better filtration techniques. As a result of these changing requirements, filtration technology has evolved considerably since 1987, and many of the old design techniques that were prevalent in those times are no longer applicable.

Methods of testing air filters, and, rating their performance have also evolved since 1987 when testing procedures in North America were largely based on ASHRAE Standard 52.1-1976 and its revisions. The ASHRAE document specified tests based on the performance of air filters when loaded with synthetic dust, and/or atmospheric dust. Now, ASHRAE has developed a new rating system using the term Mean Effective Reporting Value (MERV), by considering filter performance over a range of particle sizes. This method is described in ASHRAE Standard 52.2-1999

This edition marks a complete revision of the “MD 15600-5 Standards and Guidelines for HVAC Filters” published in 1987.

Chapter 2 Air filter types

2.1 *Filter Types: General*

There are essentially two types of filters used in HVAC work: particulate filters and gas phase filters. As the names imply, these two types of filters remove either particles or gaseous pollutants, or, sometimes, odors associated with gaseous pollutants.

Gas phase filters often use activated carbon to remove the unwanted substances in gases, such as odors; in general, this type of filter is less often used in HVAC work, and the methods of test are still largely under evolution.

Particulate filters are generally based on one or more of four basic operating mechanisms, as indicated in Fig.2.1. In addition, some particulate filters use electrostatic separation. These mechanisms are described below.

Straining

This is a fairly coarse method of filtration, in which particulates are strained through openings smaller than the particles being removed. This mechanism is often used in pre-filters.

Impingement

This occurs when larger particles in airstreams cross over the streamlines to impact the filter media, and remain there under the action of attractive forces between the media and the particles. To enhance the filtration efficiency, a viscous coating may be applied to the filter media.

Interception

At low air velocities, particles are intercepted from the airstream under the action of attractive forces acting at a distance between the media and the particles. This mechanism differs from Impingement because the particles do not hit the filter media, hence the action can occur over a larger distance from the media fibres. The effect is more pronounced for larger particles at low air velocities.

Diffusion

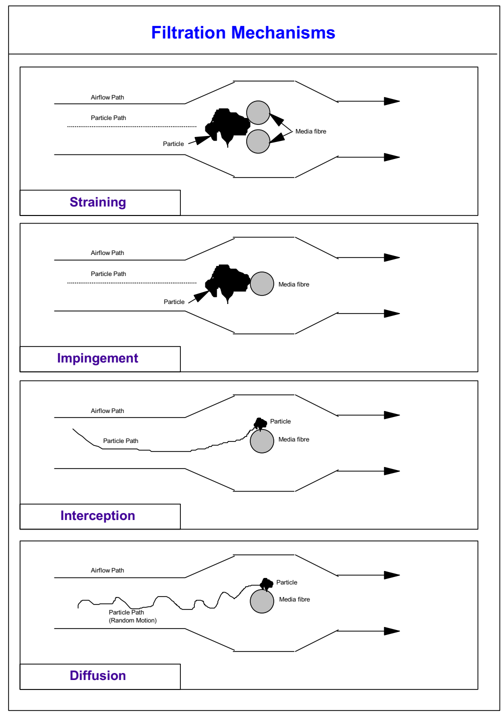
Very small particles move randomly in the airstream due to the impact of molecules. This produces an erratic path for the fine particles, allowing them to be captured by the filter media due to forces of attraction. The effect is more pronounced for smaller particles at low air velocities. Hence this method is suitable for higher efficiency filters, but it requires larger filtration area, to reduce the air velocity. This mechanism is often used in pleated filters.

Electrostatic Separation

This filtration mechanism utilizes electrostatic forces to capture particles in the airstream. Some particles may carry a natural charge, and the filter plates may also be given a charge during manufacture. The particles are captured by the charged plates under the action of electrostatic forces. Electrostatic filters operate at highest efficiency when new, but the efficiency decreases rapidly as the filter media accumulates particles with continued usage.

For more details on these filter operating mechanisms, refer to ASHRAE Handbook 2004 – HVAC Systems & Equipment, Chapter 24.

Fig 2.1: Air Filter Operating Mechanisms



2.1.1 Disposable Filters

These filters are designed for removal of coarse particles greater than 10 microns, such as pollen. They generally use fiberglass or other synthetic filtration media. They are generally rated at around MERV 1 to MERV 5, based on ASHRAE tests (See Section 3.3 for ASHRAE filter rating methods). This type of filter is based on the straining mechanism.

Many residential panel filters are of this type.

2.1.2 Washable filters

Washable filters are designed for coarse filtration, generally in the MERV 2 range. They typically use washable aluminum mesh as the filtration media. They are useful for filtering out dust mite, sanding dust and, other coarse particles. This type of filter is based on the straining mechanism.

Many residential filters are of this type.

2.1.3 Automatic Roll Filters

This type of filter uses automatic roll type filter media, and is generally used as a pre-filter in the MERV 1-5 range. This type of filter is based on the straining mechanism, and sometimes impingement.

2.1.4 Electrostatic Air Filters

Sometimes referred to as electrostatic air cleaners, this type of filter may use self charging polycarbonate material as the filtration media, and is useful for filtration of large particles of 10 micron or more, such as paint dust, carpet fibers, and, textile fibers. They are available in up to MERV 4 rating. It should, however, be noted that the MERV rating method is not very accurate when applied to electrically charged filtration media.

Typically, the filter consists of an ionization section and a collecting plate section. In the ionization area, the air stream passes between plates that are positively and negatively charged, with potential differences of up to 35 kV. This causes ionization of the particles, and these are then passed through the collection plates, where they adhere to the plates under the action of electrostatic forces. The collection process is sometimes augmented by using adhesive materials such as special oils.

This type of air filter can operate at up to 98% efficiency at low air flow rates in the 0.8-1.8 m/sec range. Efficiency decreases as the collecting plates become loaded with particles. Frequent cleaning of air cleaner cells is required to maintain the efficiency level.

If the electrostatic filter is improperly applied, the particles passing through the device may carry a residual electrical charge, which tends to drive these charged particles to walls and interior surfaces. Thus, in some cases, a low efficiency electrostatic filter can blacken interior surfaces of the ductwork, etc. faster than if no filter was used.

Electrostatic filters produce some ozone, like all high voltage devices, but with proper selection of the equipment the ozone generation can be kept within acceptable limits.

2.1.5 Pleated Filters

In this type of filter, the active surface area is extended using pleating. The filtration media is often a cotton-polyester blend, mounted on a cardboard frame. They are generally effective in the 3-10 micron particle range for removal of particles such as mould spores, and are generally available with up to MERV 8 rating. Some of the newer types of pleated filters are available in MERV 11, and are effective for capturing particles as small as 1 micron.

This type of filter uses straining and impingement as the operating principle.

2.1.6 Cartridge Filters

This type of filter uses synthetic media with a viscous coating, and operates in the MERV5-8 range. This type of filter uses straining and impingement as the operating principle.

2.1.7 Box Filters

This type of filter uses rigid box construction, sometimes using paper media, operating in the MERV9-14 range, with depths in the 150-300 mm range. They are widely used as the final filters in commercial buildings. This type of filter uses straining, impingement, interception and sometimes diffusion, as the operating principle.

2.1.8 Bag Filters

This type of filter uses microfine fiberglass or synthetic filtration media, in a flexible configuration. They are used as final filters, in the MERV 12-16 range. This type of filter uses straining, impingement, interception and sometimes diffusion, as the operating principle.

2.1.9 High Efficiency Particulate Filters (HEPA Filters)

These are amongst the most efficient particulate filters available today. They generally use wet-laid ultrafine fiberglass paper media. The paper is much more dense than in other filter types, and is able to remove most of the particles in the 0.3 micron range. New and improved media allow even better removal of microscopic particles down to 0.12 microns or smaller. They are designed for use at low duct velocities of 1.3 m/sec or less, with high pressure drops up to about 500 Pa. These are often referred to as Ultra Low Penetration Air (ULPA) Filters or Super Ultra Low Penetration Air (SULPA).

Most standard HVAC applications do not require this level of filtration but there are some specialized applications where HEPA filters may be required. These applications include: supply air filtration in hospital operating rooms; critical manufacturing applications; and laboratories.

2.1.10 Gas phase filters

Compared to particulate control, gas phase pollution filtration is a relatively new and complex field, although some types of gas phase filters have been in use for 15 years or more. Particle filters do not effectively remove gases and associated odors; for such applications, gas phase filters should be used.

Gas phase filters, as used in HVAC applications, use either physical adsorption or, chemical absorption (also called chemisorption). Physical absorption results from the electrostatic interaction between the molecules of a gas or vapour and a solid adsorbing surface. Activated charcoal works well when used as an adsorbent due to its large surface area. It is widely used because of its low cost. Other solid absorbents include silica gel, activated alumina, zeolites and porous clay.

Chemisorption on the other hand, occurs when the sorbent attracts gas molecules to its surface due to a chemical reaction. One example of a chemisorbant is potassium permanganate which is a strong oxidizing agent. This is impregnated into an alumina or silica substrate. It oxidizes organic contaminants such as formaldehyde into benign compounds like water and carbon dioxide that are released back into the air stream. Chemisorption is generally slower than physical adsorption and the active reagent needs to be recharged from time to time. Its use is, however, required for removal of specific gaseous pollutants that are not trapped by physical adsorption media.

Gas phase filtration is often used in kitchens or in archive type facilities where there is continuous generation of gaseous pollutants. It may also be required in specialized applications such as protection of buildings against airborne threats.

2.1.11 UVGI Systems

Ultra Violet Germicidal Irradiation systems are often used for destroying bacteria, microbial contaminants in the air stream. These systems often contain built-in air filters.

Evidence about the effectiveness of these systems for destroying microbial contaminants is still inconclusive. They are ineffective against spores, but may offer some protection against bacteria and viruses. They offer little protection against mould. In its document "Technical FAQ: ID 23", ASHRAE states that attempts to deactivate viruses with ultraviolet light have not proven reliable or effective enough to be recommended by most codes as a primary infection control measure.

The use of UVGI systems should, however, be considered for additional protection against microbial contaminants in high risk environments such as hospitals.

2.2 *Filter Types based on CGSB*

The Canadian General Standards Board (CGSB) uses a different terminology for filter types in its Air Filter Standards, published in the mid-eighties and nineties. The terminology is summarized in Table 2.1.

Table 2.1: Filter Types based on CGSB

Standard	Title	Date	Type & Grade	Description
CAN/CGSB –115.10-M90	Disposable Air Filters for the removal of particulate matter from ventilating systems	1990	Type 1	Throw-away filter cell
			Type 2	Replacement media for permanent frames
			Grade A	Standard dust-holding capacity
			Grade B	High dust-holding capacity
CAN/CGSB –115.11-M85	Filters, Air, High Efficiency, Disposable, Bag Type	1985	Class 1 Class 2	Rated in accordance with CAN4-S111
			Grade A	80% initial, 85% average efficiency*
			Grade B	58% initial, 76% average efficiency*
			Grade C	33% initial, 50% average efficiency*
CAN/CGSB –115.12-M85	Filters, Air, Medium Efficiency, Disposable, Bag Type	1985	Class 1 Class 2	Rated in accordance with CAN4-S111
			Category 1	45% nominal efficiency*, 1.2cu.m.sec
			Category 2	45% nominal efficiency*, 0.95 cu.m/sec
CAN/CGSB –115.13-M85	Filter Media, Automatic Roll	1985	Grade 1	75% arrestance, 600 g/cu.m dust-holding capacity
			Grade 2	65% arrestance, 500 g/cu.m dust-holding capacity

Standard	Title	Date	Type & Grade	Description
CAN/CGSB –115.14-M91	High efficiency cartridge type supported air filters for the removal of particulate matter from ventilating systems	1991	Class 1 Class 2	Rated in accordance with CAN4-S111
			Grade A	95% nominal**
			Grade B	85% nominal**
			Grade C	55% nominal**
CAN/CGSB –115.15-M91	High efficiency rigid type air filters for the removal of particulate matter from ventilating systems	1991	Class 1 Class 2	Rated in accordance with CAN4-S111
			Grade A	95% nominal**
			Grade B	85% nominal**
			Grade C	55% nominal**
CAN/CGSB –115.16-M82	Activated Carbon for Odor removal from ventilating systems	1982	Type A	Natural grain 100% coconut shell carbon
			Type B	Pelletized 100% petroleum –based carbon
			Size 1	6 to 10 mesh
			Size 2	6 to 8 mesh

Standard	Title	Date	Type & Grade	Description
CAN/CGSB –115.17-95/IES-RP-CC001.3-1993	HEPA and ULPA filters	1995	Types A to F	99.97% to 99.999% efficiency on various particle sizes ranging from 0.1 to 0.3 microns; refer to the Standard for details
			Grades 1 to 5	Various construction grades are based on fire-resistance, and conformance to US military standards, Underwriters Laboratory listings, and, Factory Mutual listings; refer to the Standard for details
CAN/CGSB –115.18-M85	Filter, Air, Extended Area Panel type, medium efficiency	1985	Type 1	8%minimum efficiency*
			Type 2	15%minimum efficiency*
			Class 2	rated in accordance with CAN4-5111-M80
			Grade A	30% nominal efficiency

Standard	Title	Date	Type & Grade	Description
CAN/CGSB –115.20-95	Polarized Media Air Filter	1995	Type 1	For use in HVAC systems
			Type 2	A stand alone air cleaning unit
				Equipped with germicidal device
				No germicidal device
			Class A	25 mm deep filter panel
			Class B	50 mm deep filter panel
			Style 1	*based on ASHRAE 52-76 atmospheric dust
			Style 2	** based on ASHRAE Standard 52

A study of the CGSB Standards reveals inconsistencies in terminology, and in the methods of rating the filters. While some refer to "arrestance" efficiency, others are based on "dust spot efficiency" and others simply refer to "nominal" efficiency. While some of the standards use "type" and "grade" to describe the filters, others use "class" and "category" as descriptors. They also refer to older ASHRAE Standards, such as 52.1-1976 that have now been superseded by other documents such as ASHRAE 52.1-1992 and ASHRAE 52.2-1999

The CGSB Standards are, however, referenced in the current National Master Specifications (NMS) and should be considered as valid until this section of the NMS is revised.

Chapter 3 Air Filters Performance Ratings

3.1 Introduction

Before evaluating air filter performance, a general understanding of the rating methods for filters is required. In North America there are two basic ratings methods that are prevalent today, using ASHRAE Standard 52.1-1992, and, using ASHRAE Standard 52.2-1999. Some portions of ASHRAE Standard 52.1-1992 relating to dust holding capacity are still valid; hence the two methods complement each other and both are required for a proper rating of filters.

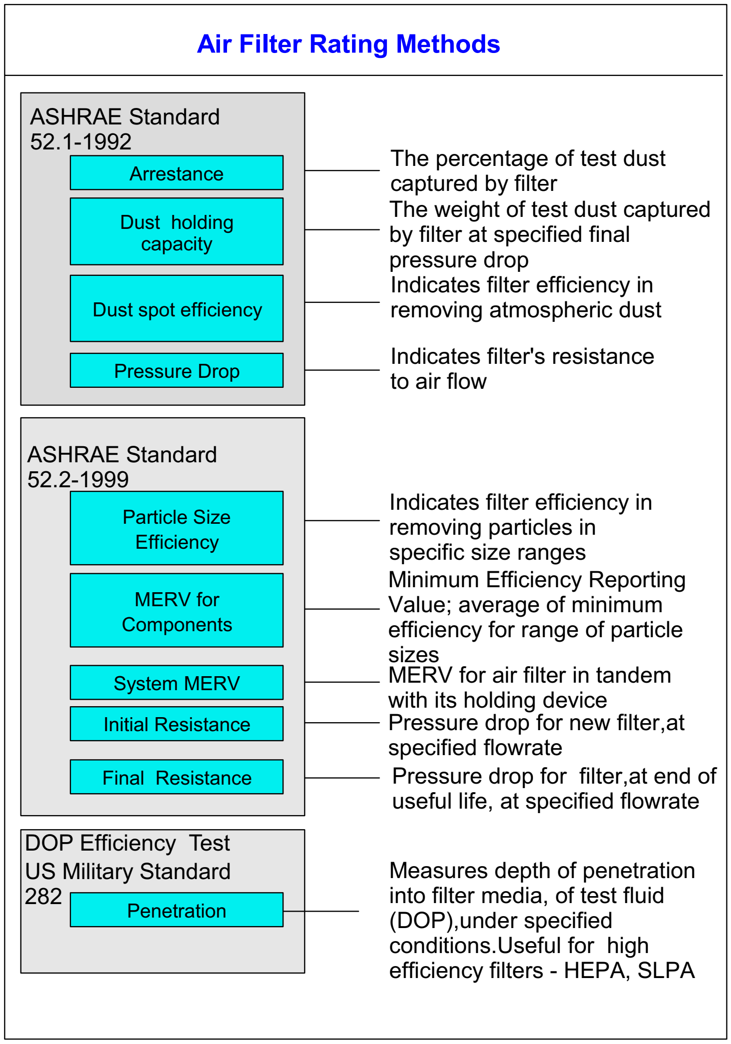
For very high efficiency filters such as HEPA and ULPA, the DOP method developed by the US Corps of Engineers is widely accepted.

Rating methods for gas phase filtration are still under development.

3.2 ASHRAE Standard 52.1 Rating Parameters

The terminology is summarized in Figure 3.1.

Figure 3.1: ASHRAE Test Parameters



3.2.1 Arrestance

The "arrestance" value of a filter is a measure of how much synthetic test dust is removed by a filter, expressed as a percentage. It is determined using the standard test procedures specified in ASHRAE 52.1.

This parameter is useful for comparing the performance of low efficiency filters, such as pre-filters. One limitation of this test method is that it uses a synthetic dust and performance with this material may not be a good measure of how the filter performs in real HVAC applications.

3.2.2 Dust Holding Capacity

This refers to the amount of synthetic dust that a filter can hold until it reaches its holding capacity. It is generally expressed in grams.

This value is useful for determining how long one filter lasts, in comparison with another. However, since the test is performed with a synthetic dust, it may not always be a good measure of performance in field conditions.

3.2.3 Dust Spot Efficiency

To overcome the limitations of the "arrestance" method, the dust spot efficiency test was developed. The "dust spot efficiency" of a filter is defined as the percentage of atmospheric dust removed by a filter. The test is conducted using outside air.

The "dust spot efficiency" value is often quoted in the manufacturer's literature and until the advent of MERV ratings, it was the standard method of rating filters.

The drawback of the dust spot efficiency test is lack of standardization, since the composition of atmospheric dust may vary from one location to another. Hence it does not yield accurate, repeatable comparisons between different laboratories and different manufacturers.

3.3 ASHRAE Standard 52.2 Test Parameters

This standard provides a test procedure, and a rating method, based on measuring filter efficiency by particle size. The earlier Standard 52.1 was based on efficiency using synthetic dust, or atmospheric dust, without consideration of particle size.

Standard 52.2 was developed due to increasing concerns about indoor air quality and the need to assess a filter's ability to remove contaminants in specific particle sizes. Standard 52.2 is not intended to replace Standard 52.1 and both Standards are required for a complete assessment of filter performance. The "arrestance" and "dust holding capacity" data provided by Standard 52.1 will remain as valuable performance characteristics, while the Standard 52.2 provides data on how the filter performs for a range of particle sizes. However, the dust spot efficiency test prescribed in Standard 52.1 may no longer be utilized as the MERV rating system becomes more widely accepted. Currently, many manufacturers still report the dust spot efficiency values in their technical documentation but there is a gradual shift towards MERV ratings.

3.3.1 Mean Efficiency Reporting Value (MERV)

To calculate the MERV rating of an air filter, a large number of filter efficiency tests are conducted for 12 particle sizes, using standard Potassium Chloride as the standard test dust. The following steps are required to determine the MERV rating of the filter:

1. The particles sizes are sub-divided into three ranges, R1, R2, and R3. Particles in the 0.3 to 1.0 micron

range are classified as R1; particles in the range 1.0-3.0 microns are classified as R2 and particles in the 3.0 to 10.0 range are classified as R3. This is illustrated in Table 3.1 below.

2. For each range, R1, R2 and R3, efficiency tests are conducted for each particle sizes within that range. The *lowest* efficiency reported for each particle size is then recorded, as shown in Table 3.1.

3. For each range R1, R2 and R3, the average of these lowest efficiency values is calculated. in the example shown, the lowest efficiencies for each particle size were 74%, 82%, 87% and, 92% for the range R1, based on the tests performed. From this data, the *average* efficiency was calculated as 84% for range R1. Similar tests were conducted for ranges R2 and R3, resulting in average efficiencies of 98% for R2 and 100% for R3.

4. The average efficiency values for each range R1, R2 and R3 are then compared with the required average efficiency values indicated in Table 12-1 in ASHRAE Standard 52.2-1999, for each MERV rating.

5. From this comparison, the MERV rating of the air filter is determined.

For the example shown, it is seen from Table 3.2 that the MERV14 rating satisfies the efficiency values for each particle size range. Hence, this filter is classified as MERV 14, according to ASHRAE Standard 52.1-1999. This procedure is summarized in Figure 3.2.

Figure 3.2: MERV Rating Procedure

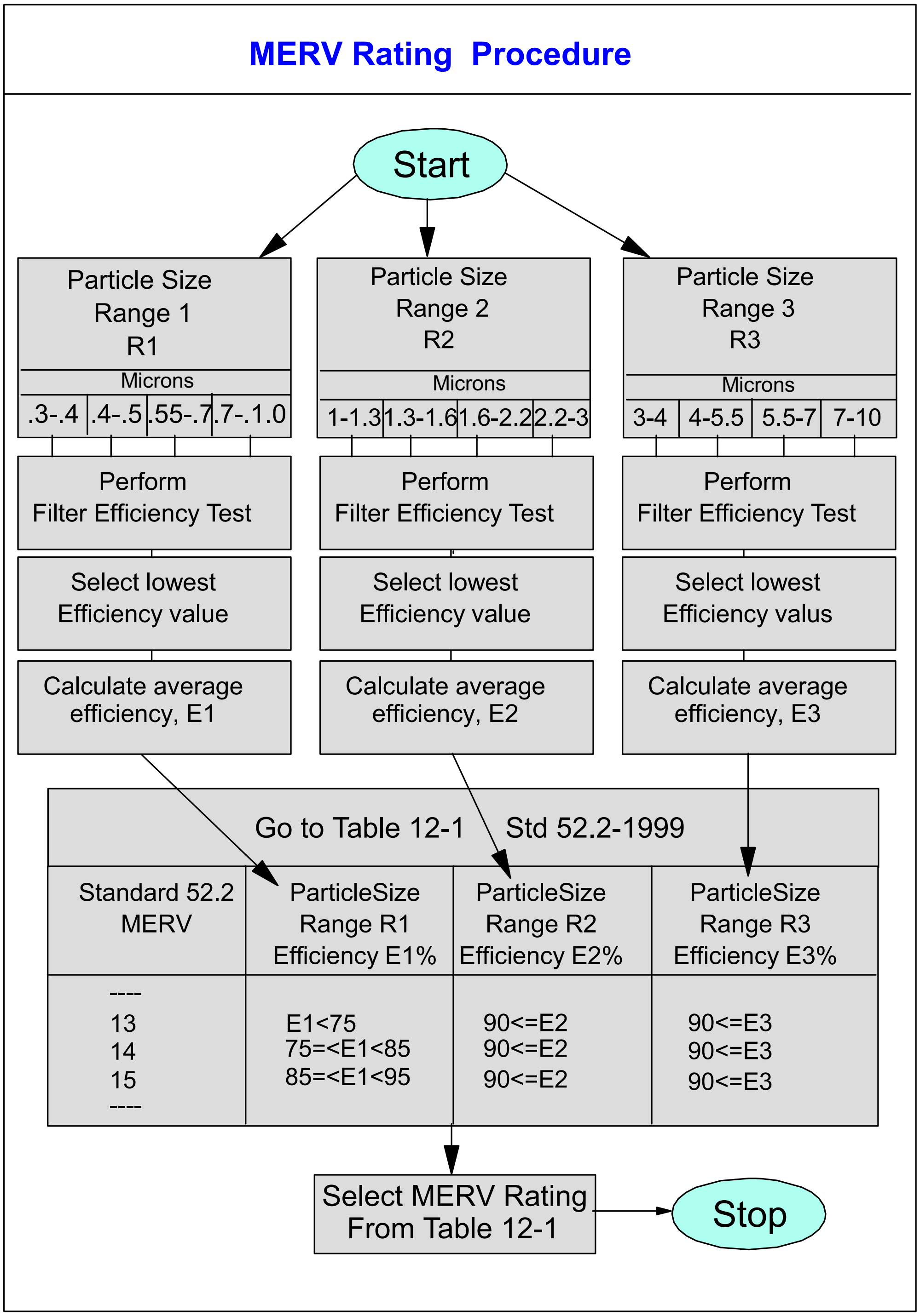


Table 3.1: MERV Rating Example

Particle Size Microns	Range	Lowest reported efficiency for each particle size, based on 6 readings for each particle size	Average filter efficiency, Particle Size Efficiency (PSE)
0.3-0.4 0.4-0.55 0.55-0.70 0.70-1.0	R1	74% 82% 87% 92%	84% (E1)
1.0-1.3 1.3-1.6 1.6-2.2 2.2-3.0	R2	96% 98% 99% 100%	98% (E2)
3.0-4.0 4.0-5.5 5.5-7.0 7.0-10.0	R3	100% 100% 100% 100%	100%(E3)

Table 3.2: Selection from Table 12-1, ASHRAE Standard 52.2-1999

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Size Efficiency, % In Size range, microns	Composite Average Size Efficiency, % In Size range, microns	Composite Average Size Efficiency, % In Size range, microns
	Range 1 0.30-1.0	Range 2 1.0-3.0	Range 3 3.0-10.0

13	E1<75	90<=E2	90<=E3
14	75<=E1<85	90<=E2	90<=E3
15	85<=E1<95	90<=E2	90<=E3

The MERV rating system offers many benefits:

- Filter performance is assessed over a wide range of particle sizes;
- Test results are reduced to a single parameter – the MERV rating–for easy comparison of different filters;
- The test procedure is standardized and the results are repeatable from one laboratory to another;
- Use of Potassium Chloride–based test dust provides more consistent results than with earlier test procedures based on atmospheric dust;

- The MERV procedure is based on the lowest efficiency values for each particle size, allowing selection of filters using their "worst case" efficiencyand

- The test method is very comprehensive and a large number of tests are performed before the MERV rating is assigned.

The MERV rating system has the following disadvantages:

- The procedure has limited value for synthetic media filters. Most of these filters incorporate an electrostatic charge to improve efficiency, and this may result in misleading data with the MERV procedure. During the MERV test, the filter is loaded with an artificial dust that can mask the dissipation of electrostatic charge that occurs in actual service. Hence the MERV rating is not very accurate for this type of filter.

- The MERV system does not provide information on arrestance, which is a useful parameter for comparing low efficiency filters, such as pre-filters. Hence, for low efficiency filters, the arrestance value should be specified by referring to ASHRAE Standard 52.1-1992.

- The MERV system does not provide information about how much dust the filter can retain, over its useful life. Hence, dust holding capacity should be specified in accordance with ASHRAE Standard 52.1-1992.

- In some applications, it is necessary to remove particles in a specific size. In these cases it is insufficient to specify the overall MERV rating. The particle size efficiency in the specific particle range should also be indicated.

3.3.2 Correlation between ASHRAE Standards 52.1 and 52.2

An exact correlation between the two test methods is not possible as they use two very different approaches and the MERV testing procedure is much more rigorous and comprehensive than the earlier approach. However, approximate cross-referencing between the two systems is possible using data provided by ASHRAE in Appendix E, Standard 52.2-1999. Excerpts from the Table are given in table 3.4.

Table 3.4: Correlation between MERV and Standard 52.1

MERV	Dust Spot efficiency	Arrestance	Typical controlled contaminant, microns	Typical application
20	N/a	N/a	< 0.30	Cleanrooms
16	N/a	N/a	0.3-1.0	Hospitals
14	90-95%	>98%	0.3-1.0	Superior commercial buildings
13	80-90%	>98%	0.3-1.0	Superior commercial buildings
12	70-75%	>95%	.01-3.0	Better commercial buildings
8	30-35%	>90%	3.0-10.0	Commercial buildings
4	<20%	75-80%	>10.0	Minimal filtration requirements Residential Window air conditioners

3.4 *HEPA Filters: DOP Efficiency Test*

This is the test method used to evaluate performance of very high efficiency filters such as HEPA filters. DOP (dioctylpthalate) is a liquid that forms an aerosol when exposed to compressed air, in the particle range of 0.3 to 3 microns.

In this test procedure, the DOP is heated to the point of vapourization, at a temperature of approximately 22 deg.C, and then re-constituted into 0.3 micron particles to form an aerosol. The aerosol is diluted with air until a concentration of 100 micrograms/litre is reached, and then passed through the filter under test. The amount of penetration is measured on the downstream side with a light scattering photometer. The depth of penetration provides a measure of the filter efficiency.

Chapter 4 Air Filter Selection

4.1 *General*

For proper selection of air filters for HVAC application, a number of factors should be considered. These may include: applicable standards and guidelines, the type of contaminants in the building, the type of project i.e. new building, upgrade to existing, or major retrofit and the flow capacity of the existing air handling systems, as discussed below.

4.1.1 Applicable Standards and Guidelines

Health Canada's guidelines require that particulates in office buildings should be less than 50 micrograms/cu. metre, based on US EPA National Ambient Air Quality Standards. This is a prescriptive requirement and these guidelines do not indicate what level of filtration is required to meet this objective.

ASHRAE Standard 62.1-2004 "Ventilation for Acceptable Indoor Air quality" requires a minimum of MERV6 filtration level upstream of cooling coils or other devices with wetted surfaces. This is, however, a very conservative requirement and most buildings should readily be able to exceed this.

PWGSC MD 15000 requires minimum filter efficiency of 60-80% for air handling units, with the exception of roof top units (RTUs). The standard, does not, however, indicate what type of filter efficiency is referred to.

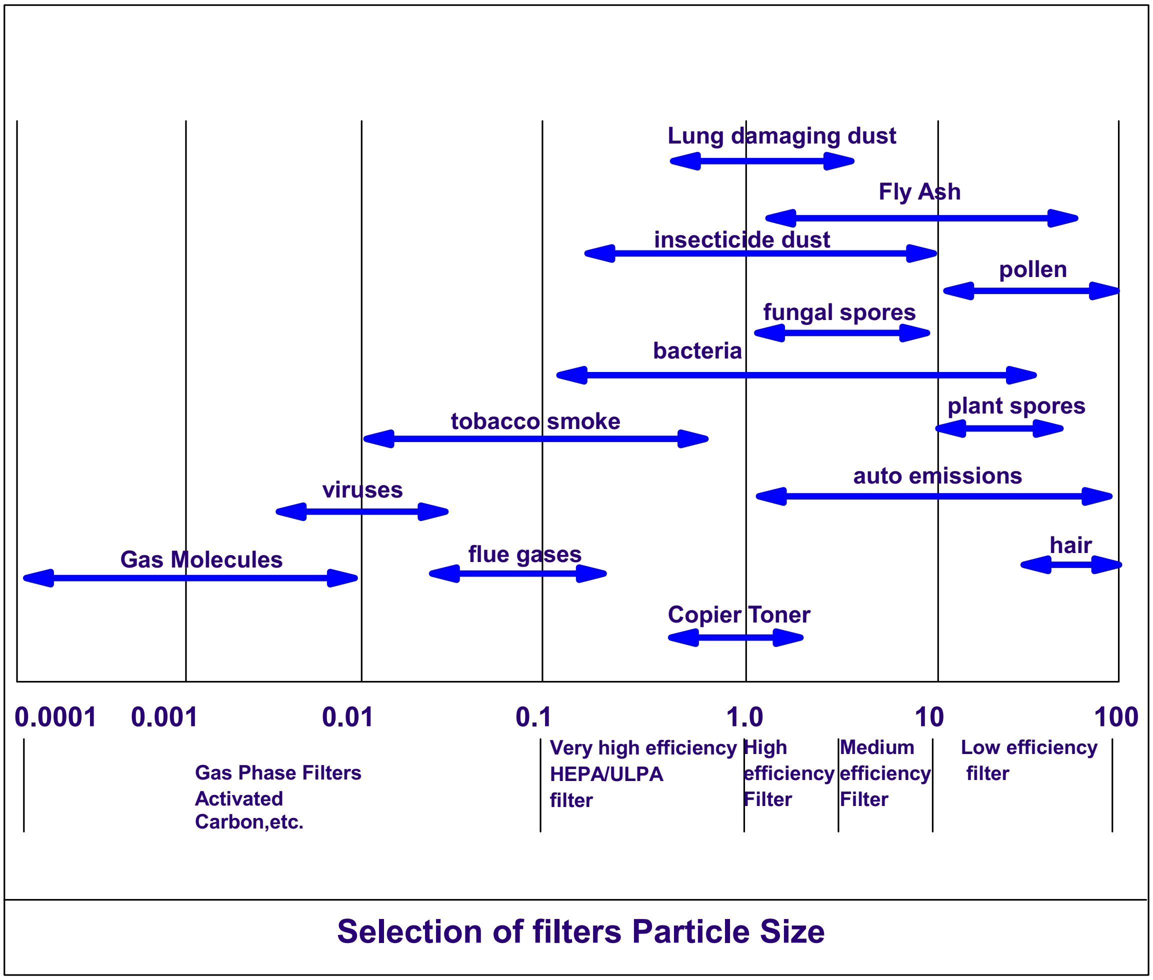
PWGSC Federal Office Building Standards require minimum MERV8 for pre-filters and recommend MERV13 for final filters, subject to meeting the energy conservation requirements.

PWGSC MD 15116-2006 Computer Room Air-conditioning Systems requires at least MERV 10 for filtration in computer rooms. If the Computer Room has human occupancy, then it may be treated like an office space, with a minimum MERV13 filtration level. See PWGSC's *Federal Office Building Standards*.

4.1.2 Type of contaminants

Contaminants that are commonly found in buildings include fungi, spores, dust, copier/toner emissions, automotive exhaust, bacteria, and, tobacco smoke. The particle size ranges for these contaminants may be estimated from Figure 4.1 below.

Figure 4.1: Filter Selection by Particle size



As the diagram indicates, the type of filter selected depends on the contaminants that are likely to be present. Plant spores, pollen and very coarse particles can be removed with low efficiency filters. For spores and dust, particulate air filters with ASHRAE MERV ratings are required. For removing bacteria, HEPA/ULPA particulate filters may be required; these filters are too fine to be rated by the ASHRAE MERV procedure.

For viruses, even HEPA filters may be inadequate and some form of gas phase filtration should be considered. Odor removal is not addressed in Figure 4.1; it generally requires gas phase filtration.

The figure also indicates that tobacco smoke cannot be filtered out effectively with particulate filters.

4.1.3 Available Pressure Drop

Pressure drop across the filter may impose a restraint on the type of air filter that can be used. Filters with low MERV ratings in the 1-8 range generally have a negligible pressure drop, for most HVAC applications.

The word "resistance" is often used as a synonym for pressure drop across the filter, as in ASHRAE Standard 52.2-1999. The initial resistance is the pressure drop across the filter when it is new. The final resistance is the pressure drop across the filter when it is dirty and needs to be replaced.

Typical values for pressure drops across filters are shown in Table 4.1, based on one manufacturer's data. These values are provided for approximate guidance only.

Table 4.1: Typical Pressure Drops (source: Airguard)

Filter Rating	Type	Equivalent MERVrating	Air Velocity FPM (metres/second)	Rated Initial resistance, inches water gauge	Rated Final resistance, inches water gauge
MERV 7	Disposal panel filter	N/A	300 (1.53)	0.11-0.13	0.5-1.0
MERV 7		N/A	500 (2.55)	0.26	1.0
72-75% arrestance	Disposal panel filter		300 (1.53)	0.07-0.09	0.5-1.0
75-80% arrestance	Disposable Panel Filter		300 (1.53)	0.1	1.0
MERV 8	Pleated panel filter	N/A	300 (1.53)	0.2-0.50	
			500 (2.55)	0.35-0.55	
MERV 11			300 (1.53))	0.13-0.26	

Filter Rating	Type	Equivalent MERVrating	Air Velocity FPM (metres/second)	Rated Initial resistance, inches water gauge	Rated Final resistance, inches water gauge
			500 (2.55)	0.3-0.58	
MERV 12			500 (2.55)	0.15-0.26	
MERV 13			500 (2.55)	0.28-0.40	
MERV 14			500 (2.55)	0.32-0.52	
Greater than MERV 16, less than HEPA	Microguard		500 (2.55)	0.80-1.0	2.0
HEPA filters			500 (2.55)	1.2-1.35	
Gas phase adsorbers	Activated carbon		500 (2.55)	0.33-0.76	
Combination particulate and gas phase filter	Activated carbon plus polyester media		300 (1.53))	0.18-0.31	
Combination particulate and gas phase filter	Activated carbon plus polyester media		500 (2.55)	0.42-0.75	

The pressure drop across the filter varies with flow rate according to the equation:

P2 = P1 * (Q2/Q1)^2

Energy loss in air filters may be estimated using the following equation:

E = Q*P*T/(N*1000)

Where

E is the Energy Consumption in KWH

Q is the Air Flow rate in cu.m/second

P is the average pressure drop across the filter in Pa.

T is the operation time in hours

N is the fan efficiency

availability.

4.2 Recommendations for Existing Buildings

The following recommendations apply to existing buildings:

1. The filters in existing buildings should be rated at MERV13 or higher, If a lower MERV filter is used, it should be changed to MERV 13 during routine maintenance, wherever it is possible to do so without physical changes to the air handling unit layout, or, changes to the fan motors/drives in order to accommodate the higher pressure drop across the new filters.

2. If provision of MERV13 filters is not readily possible, then the particulate levels in the building should be measured using a particulate counter (See Section 6, reference 10) and air filtration changes should be considered if the particle count of 50 micrograms/cu.m is exceeded, in accordance with Health Canada guidelines.

3. For existing roof top units, heat pumps, and, terminal units in existing buildings, a minimum of MERV 8 is recommended. However for new roof top units, a MERV rating of 11 or higher is recommended, based on product

4.3 Recommendations for retrofits to existing buildings

1. Major retrofits should be treated the same as new buildings for the purposes of air filtration. For minor retrofits, the requirements for existing buildings should apply.

This Section is applicable only if PWGSC is responsible for the maintenance and operation of the building.

4.4 Recommendations for Leased Buildings

The design criteria indicated in this document will apply to leased buildings but the operation and maintenance of the air filtration system will be the responsibility of the lessor.

4.5 Recommendations for new buildings

1. For new buildings, and, major retrofits to existing air handling units, a minimum filtration level of MERV13 should be provided. However, for new roof top units (RTUs), a minimum rating of MERV11 is recommended. Pre-filters should also be provided, with a minimum of MERV 8 rating.

2. Where protection against chemical or biological hazards is required, consider using Air Filtration with a

minimum of MERV 14 rating. In addition, consider the use of UVGI systems for protection against bio-contaminants.

Special areas, where generation of contaminant gases can occur, should also be equipped with gas phase filters.

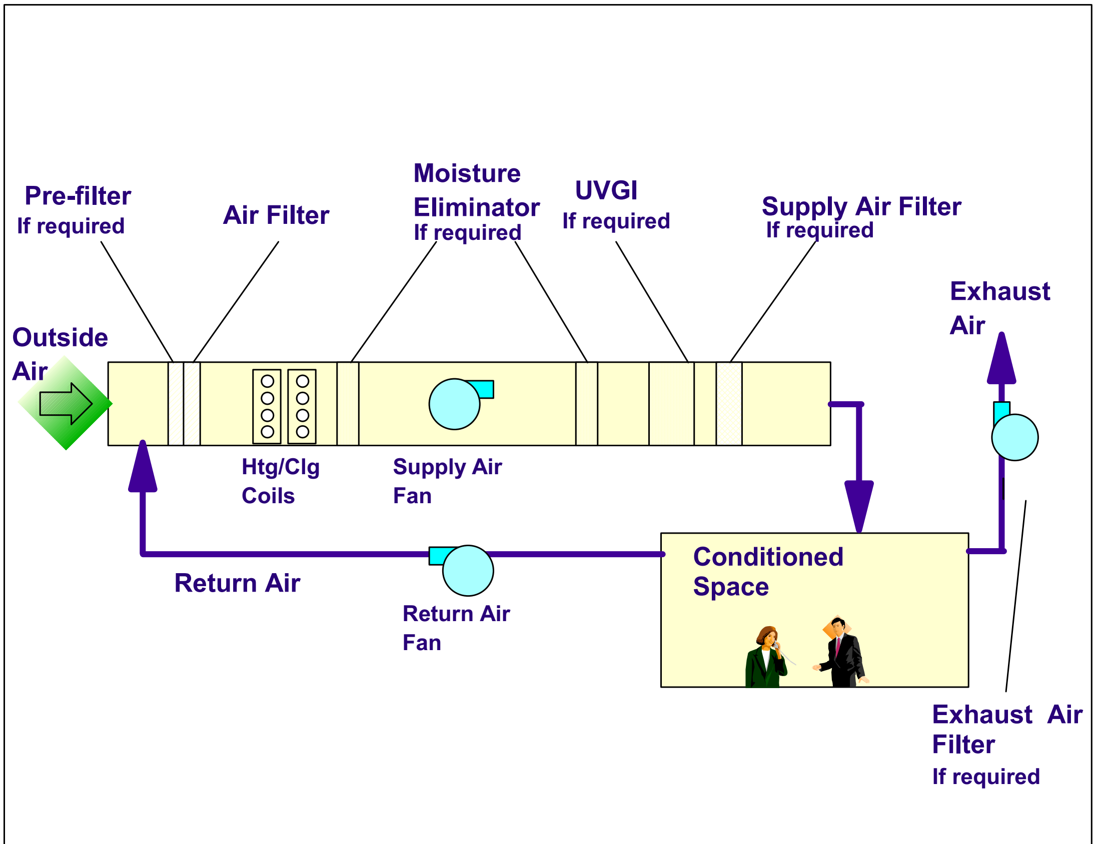
4.6 Air Filters Installation

Proper installation of air filters and air filter banks is of prime importance, as air leakage from the filter assembly can reduce efficiency. As filter efficiency increases, greater attention should be paid to the rigidity and sealing effectiveness of the frame.

Air filters should be installed in the mixing chambers of air handling units. In some cases, filtration of outside air and/or supply air may be required. Pre-filters should be placed upstream of the heating or cooling coils, and other sensitive air-conditioning equipment for best protection against dust.

A typical filter installation is shown in Fig 4.1 below. All of these elements will not be required for all systems. For example, a commercial office building may not require a final filter downstream of the supply air fan; such filters would, however, be required for hospitals and laboratories.

Figure 4.2: Air Filters Installation



Air Filtration System Installation

4.7 *Air Filter Operation and Maintenance*

Proper installation is the first step towards maintaining the efficiency of the air filters. It is important to ensure that there is no leakage path outside the filter element, so that all the air is filtered.

A filter replacement schedule should be set up, in accordance with the manufacturer's instructions. In addition, differential pressure switches should be provided across the filters, connected to the Building Automation System wherever feasible, to generate an alarm whenever the final resistance of the filter approaches a pre-set value.

Electrostatic filters may require more frequent maintenance and may require monitoring of ozone levels, as high voltage electronic devices generate ozone.

UVGI systems require frequent maintenance, including replacement of bulbs at regular intervals. The systems should be regularly inspected and tested, in accordance with the manufacturer's instructions.

Chapter 5 Glossary

Activated Carbon Filter

- Filter containing an activated charcoal or carbon, designed for removal of odours.

Arrestance

- This is the filter efficiency, expressed as a percentage, based on its efficiency in collecting synthetic dust, as described in ASHRAE Standard 52.1-1992. This term is generally applied to low efficiency filters.

Air Cleaner

- Device for removal of suspended particles from air stream.

Air Filter

- Same as Air cleaner.

Disposal filter

- Device with a disposable filter element.

Dust holding capacity

- The weight of dust, expressed in grams, captured by a filter until it reaches the final resistance value, as described in ASHRAE 52.1-1992.

Dust Spot Efficiency

- This is the filter efficiency expressed as a percentage, based on atmospheric dust and is generally applied to high efficiency filters. It is based on procedures described in ASHRAE Standard 52.1-1992. "Dust spot efficiency" has been replaced by the Mean Effective Reporting Value (MERV) designation, but currently both terms continue to be in use.

Initial resistance

- Pressure drop across the filter when new and clean, at rated air flow. Expressed in cm WG or inches WG.

Final resistance

- Pressure drop across the filter at the end of its useful life, at rated air flow. Expressed in cm WG or inches WG.

Filter Efficiency

- Normally expressed as a percentage. When used loosely, without indicating method of test, the term carries little meaning and may be misleading. Filter efficiency based on "dust spot efficiency" is very different from the filter efficiency based on "arrestance".

For example, consider a filter described as having 85% efficiency. If this refers to "dust spot efficiency", then Table E-1 in ASHRAE Standard 52.2-1999 indicates that this is equivalent to a MERV13 rating.

If, however, the effciency refers to "arrestance", then Table E-1 indicates that this is equivalent to a MERV 6 rating.

Hence it is critical to refer to either "dust spot efficiency" or "arrestance", and not simply to filter efficiency.

Mean Effective Reporting Value (MERV)

This refers to the filter efficiency based on the procedures described in ASHRAE 52.2-1999. The MERV designation is, in essence, a composite number based on the performance of the filter for a number of particle sizes. MERV ratings may be correlated with "dust spot efficiency" using Table E1 in Standard 52.2 – 1999.

Particle Size Efficiency

- This refers to the efficiency of the filter for a given particle size, based on the procedures described in ASHRAE 52.2.-1999.

Chapter 6 References

1. PWGSC “Federal Office Building Standards”

2. ASHRAE Standard 52.1 –1992 “Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices used in General ventilation for Removal of Particulate Matter”

3. ASHRAE Standard 52.2-1999 ”Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size”

4. ASHRAE Standard 62.1-2004 “Ventilation for Acceptable Indoor Air Quality”

5. CGSB Standards “Air Filters”

6. Health Canada “ Indoor Air Quality in Office Buildings: A Technical Guide”

7. US EPA “Ambient Air Quality Standards”

8. Canada Labour Code, Part II

9. ASHRAE “Technical FAQ; ID 23 – UVGI Systems”

10. Application Note: Growing your business through indoor air quality particulate profiling.

11. http://www.cuthbertsonlaird.co.uk/PDF/IAQ%20Profiling.pdf