



Zen of Filter Classes

*By R. Vijayakumar, PhD
Aerfil
Liverpool, New York*

and

*Marco Adolph, PhD
Trox Brasil
Curitiba – PR – Brazil*

Abstract

Air filters of today are specified to meet several classes specified by various national standards. Although many of these filter classes appear to offer similar filter performance, none of them are equivalent. Even the attempts at an international standard are not expected to resolve this situation. In this article we argue that drastically reducing the number of filter classes will not only reduce the confusion in the market, but will not adversely affect outcome on the occupants or the processes that are served by the filtration systems. Given that the variability in the test methods is large enough for adjacent filter classes in many standards not to be statistically different, there is strong justification for taking this approach.

Introduction

At the outset, we wish to unequivocally state that we are not practitioners of Zen, nor are we trained in the practice of this ancient tradition. We use the term Zen in our title simply to convey that we are acknowledging the focus on the simple, which is just a small aspect of the practice of Zen. No disrespect to this ancient tradition is intended or implied. With humility, we wish to learn from any Zen masters who read this paper.

About the Authors

R. Vijayakumar is the founder and head of Aerfil, a consulting company that provides technical and business solutions and training support for the filtration and contamination control industry. His clients include major filtration companies in China, Brazil and India. A Ph.D. in particle technology, he has over 30 years' experience in leading filtration and particle test instrument companies, is an advisor to NASA for air filtration systems for space habitat, has been on the faculty of the short course on air and gas filtration at the University of Minnesota and is a Distinguished Visiting Professor at the Chinese Academy of Building Research. He has taught courses in filtration and cleanroom designs as an ASHRAE DL, and has served as the President of the IEST, the premier contamination control organization in the US. Currently, he chairs standards development committees at the ISO and in the US for high efficiency filters.

Marco Adolph is a bachelor in mechanical engineering from Federal University at Parana (UFPR – Brazil). He completed his masters in mechanical engineering in 2002, and a Ph.D. in mechanical engineering in 2006, both from State University at Campinas (SP – Brazil). He completed his MBA in project management at Fundação Getulio Vargas in 2012. He has been working for TROX since 2006, with experience in R&D in Germany and product management in Brazil. He was head of the Brazilian delegation at ISO TC142 from 2008 to 2012. He also works at the Brazilian standardization groups for filters and filtration equipment, and is a part of Brazilian Society for Contamination Control (SBCC).

Over the past twenty-five years, air filter test standards have proliferated with every major nation or region establishing its own standard. These standards are often similar but not identical. As a result, the number of similar but not identical filter classes has also proliferated to almost the point of being meaningless. The measurement variability in many of these classification schemes, especially for the lower efficiency ventilation filters, is large enough for adjacent filter classes in many standards not to be statistically different. This paper discusses ways of reducing the number of filter classes and the potential effect on the quality of air delivered. This discussion is not for recommending specific new, and fewer, filter classes, but more as a challenge to all the professionals to take a fresh look at what these filter classes really mean to the one that matters most: the consumer. As a matter of reference, one should keep in mind that until late 1980s, in most of the world there were just a few filter classes as defined by *ASHRAE 52.1*, namely 90-95%, 80-85%, 60-65% etc. In fact, these terms are still in current conversational use in many parts of the world. Similarly, for High Efficiency (HEPA) filters, one still relates to the filter class defined as 99.97% dating back over 50 years.

Filter Classes and Standards

For this paper, the discussions are limited mainly to European Norms *EN 779* and *EN 1822*, Institute of Environmental Science and Technology, USA (IEST), and *ASHRAE 52* standards, simply because these are more widely followed around the world. Although filters in the higher efficiencies are mostly specified either according to regulations, or by unique industry specific cleanroom requirements, lower efficiency HEPA filters are also used for general ventilation and in hospitals. Thus, this article includes discussions of ways to reduce the number of ventilation filter classes as well as HEPA filter classes.

Reduced Number of Filter Classes

First, let us consider the filter classes for ventilation filters. The case for reducing the number of filter classes of ventilation filters can be made from several points of view, each of which we will examine. An examination of *Figure 1* shows that the range of filter efficiencies relevant to these standards has increased

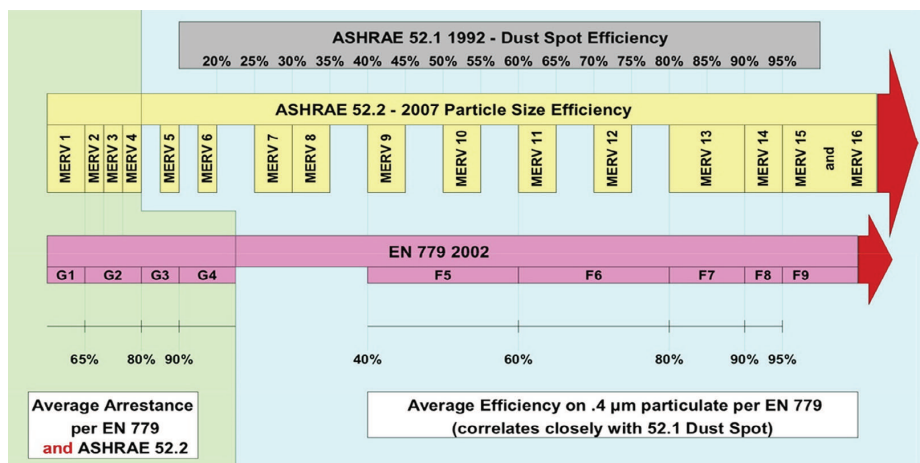


Figure 1: Comparison of filter classes (reprinted from the literature of Blue Heaven Technology, USA)

Table 1: New filter classes

ASHRAE 52.2			EN 779		
Current	Case 1	Case 2	Current	Case 1	Case 2
MERV 1	MERV 2	MERV 2	G1	G2	G2
MERV 2			G2		
MERV 3			G3	G4	
MERV 4	MERV 4	G4			
MERV 5		MERV 5	F5		F6
MERV 6	MERV 6		F6		
MERV 7			MERV 8	F7	F8
MERV 8	MERV 8	F8			
MERV 9		MERV 10		F9	H10
MERV 10	MERV 10		H10		
MERV 11			MERV 11		
MERV 12	MERV 12				
MERV 12		MERV 14			
MERV 14	MERV 14				
MERV 15		HEPA			
MERV 16/HEPA	HEPA				

from about 5 classes in the old *ASHRAE 52.1*, to 9 in *EN 779* and to 16 Minimum Efficiency Reporting Values (MERV) in *ASHRAE 52.2*. While the additional classes may be perfectly useful in differentiating products, they may not add any more to the comfort of the air for the user, especially in the lower efficiency range where most filters are used to protect equipment and second stage filters and not people. Hence, simply on the basis of proliferation of classes in new versions of standards, one can make the case that we can quite easily live with as few filter classes as in earlier times. Although it is theoretically possible to divide the range of filter efficiencies into finer and finer sub-ranges or classes, because of the measurement and manufacturing variability,

differentiating such fine differences is not practical; these difficulties were discussed in the authors' personal conversations with laboratory specialists and at some technical committees. Such practical differences have been known to sometime cause filters of a specified class to be classified one or more classes different than the one specified. Thus, if the variability in each filter class is quantified as \pm one class, the number of filter classes in both *EN 779* and *ASHRAE 52.2* can be substantially reduced and the total number of classes approaches the number in the now obsolete *ASHRAE 52.1*. The new classes are shown in *Table 1*.

In *Table 1*, two possible means for reducing the number of filter classes are

Filters in Common Use

Some examples of filters in common use are given in Figure 2 to 6 (photos courtesy Trox Brasil, Brazil).



Figure 2: Cleanroom ceiling filter, ISO 35-45



Figure 3: Filter media and pleated filters for furnace and pre filter applications



Figure 4: V bank filter, F7 - ISO 35 for HVAC and similar applications



Figure 5: Minipleat HEPA filter for cleanrooms, hospitals and similar applications



Figure 6: Filter media roll and pocket filters for HVAC use

shown. In the extreme case, the filter classes are reduced to become non-overlapping as shown in Case 1 in the Table. That is, since the filter class can have a variability of ± 1 class, the interval between adjacent classes will be at least two classes apart in the current standard classifications shown, e.g., the new class will be MERV 2, 5, 8, 11. Or for a less drastic reduction in the number of filter classes, alternate filter classes can be eliminated as shown, e.g., G2, G4, F6, F8, H10. In either case, the resulting number of filter classes is reduced to a number closer to that in vogue in the past.

So far, reducing the number of filter classes on the basis of existing classes has been discussed, without consideration for the benefits of using a filter of a specific filter class. Most applications of ventilation filters are either for protecting equipment or for the

Table 2: Filter class replacement for commercial fiberglass pocket filter

Filter class	Flow	dP [Pa]	CADR	Replacement filter class	Replaced CADR	Increase in CADR
F9	3400	140	3307	F8	3774	468
F9	3400	140	3307	F7	3757	451
F8	3400	120	3145	F7	3468	323
F7	3400	100	2890	F8	2359	(21)
F5	3400	50	1700	F6	1785	85
F6	3400	70	2380	F5	2125	(255)

comfort of the people in the space supplied with the clean air. Clean air delivery rate (CADR) is one of the accepted parameters to determine the quality of air supplied. CADR is the product of the airflow rate and the efficiency of the filter. That is, one can achieve the same CADR by using a higher flow rate and lower efficiency or with a lower flow and higher efficiency.

For this analysis, data and curves for initial pressure drop and air flow, available on the internet, from one major filter manufacturer are used. The CADR in each case was computed using the mid point efficiency of the filter class and the rated flow. For computing the CADR for the replacement filter class, the flow rate for the replacement filter class was increased or decreased according to the change in resistance.

First, data for pocket filters made with glass fiber media is examined. As seen in Table 2, replacing F9 filters with F8 and F8 with F7 actually results in an increase in CADR. Even replacing an F9 filter with an F7 results in a much higher CADR. Hence, all three filter classes, F9, F8, and F7, can be replaced by F7. In all cases there will be an increase in CADR. Although there is a small decrease in CADR if F7 is replaced by F8 filters, as seen in the data, one can replace all three filter classes F9, F8 and F7 with F8, the mid point of the filter class range

as shown in Table 1, without adversely affecting the quality of delivered air as measured by CADR. A similar result is seen when an F5 filter is replaced by an F6; whereas replacing an F6 with an F5 shows a decrease in CADR, the change is about 10% and may be an acceptable replacement.

For the higher efficiency filters, both EN 1822 and IEST standards offer test methods and classification schemes for filters with efficiencies above 85%. Although seemingly different, both standards classify filters from their efficiencies determined at, or close to, the filter's Most Penetrating Particle Size (MPPS). Hence, for the purpose of our analyses, they are assumed to be similar standards. The classification schemes for high efficiency filters in the two standards do not offer the same dramatic overlap seen in the ventilation filters. Thus, the analyses on reducing the number of filter classes will be based only on their performance and CADR. We have restricted the discussion to EN 1822 in this article. In this case, the CADR is computed from the efficiency

Table 3: Filter class replacement for HEPA filter

Filter class	Flow	dP [Pa]	CADR	Replacement Filter class	Replaced CADR	Increase in CADR
H12	3000	240	2992	H11	3291	299
H13	3000	265	2999	H12	3291	292
H 14	1100	231	1099	H 13	1099	~ 0
U 15	605	460	605	H 14	604.99	~ 0

of the filter class as specified in *EN 1822*.

As seen in the data, replacing U 15, H 14, H13 or H12 filters with one of a lower class results in a higher or equal CADR. That is, these four classes can be replaced without affecting the quality of air delivered. Since H13 and higher classes are often used in regulated industries, it may be more acceptable to eliminate H12 and replace it with H11 for general ventilation and similarly replace U15 with H14 for non cleanroom applications. One could simply use H 11 and H14 for most applications outside of cleanrooms without loss of clean air delivered.

Summary

The classification of general ventilation filters has expanded from a few about twenty five years ago to 16 in the US Standard and 10 in the European Norms. Since many of these classes overlap in performance or are within the potential variability in measurements, an example of reduced number of classes—6 for ASHRAE and 4 for the European Norms—has been presented. Analyses of CADR delivered by commercial filters of adjacent filter classes shows that replacing filters with filters of an adjacent filter class does not seriously affect the CADR. In several of the cases examined, one obtained a higher CADR when a lower filter class was used to replace a higher class filter, thus offering a potential for cleaner air delivery at lower pressure drops. Similar

analyses of the CADR of HEPA and ULPA filters most often used in non regulated industries or non critical applications, showed that the four filter classes between H11 – U15 (*EN 1822*) can be replaced with just two without adversely affecting the cleanliness of the delivered air. As a practical recommendation, perhaps specifying just H11 and H14 filter classes will be adequate for most non regulated industries or non critical applications that currently specify H11 – U 15 filters.

Future Work

Analyses of data from additional commercial filter types and classes, as well as experimental measurements will be required to make a stronger case for reducing the number of filter classes and returning to the simplicity of a few filter classes of the years past.

References

- ASHRAE 52.2 – 2007: *Method of Testing Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*, ASHRAE, USA
- ANSI/AHAM AC-1: *Method for Measuring the Performance of Portable Household Electric Room Air Cleaners*, AHAM, USA
- EN 779 – 2002: *Particulate Air Filters for General Ventilation: Determination of the Filtration Performance*
- EN 1822- 2009: *High Efficiency Air Filters (HEPA and ULPA)*, Part 1 - 5 [↗](#)