

CHAPTER 12

Filter Media Standards

References have been made occasionally throughout this Handbook to standards as they affect filter media and/or filter testing. A coherent look is now given at the whole range of standards, from several sources.

12.1 Introduction

Particularly in those parts dealing with characterization of materials or testing of filtration performance, the relevant standards have featured in earlier chapters, mainly as guidelines to methods of characterization or testing. Many of these standards are produced by central organizations, but there are also equally valuable documents available from organizations specific to an industry sector. These bodies are listed briefly first, followed by a reasonably complete listing of the relevant standards for filter media in particular, and filter testing in general, plus some comments on the way in which standards are developed and confirmed.

No attempt is made here to expand the details of most of the standards beyond simple listing of the titles – the list is too extensive for that.

12.2 Standards Organizations

Most developed countries have national standards offices, charged with the development and publication of standards for materials and processes in all walks of life. Some of these have long histories of preparation and publication of standards that have had a major effect upon industrial development. Not too surprisingly, a significant number of standards have to do with safety procedures, so that, in the case of filtration, procedures relating to fluid power installations were among the earliest, and remain among the most important. The need for established procedures for the demonstration of the efficiency of high-grade air filters, and for the production of safe water, has led to a fresh burst of standard creation.

However, it is not only national bodies that produce key guidance documents. Several industry-related associations have seen particular needs for standards, and filled them well, with documents that have become classics of their kind – ASHRAE is perhaps the prime example of this kind of body.

With the growing importance of international business, an international standards organization was soon established, and there are now major ISO standards in all fields of filtration work, and most new national standards are related to their equivalent ISO document. The European countries have also established a continent-wide organization, to ensure conformity of national standards.

The leading bodies in the issuance of standards are listed in Table 12.1, which includes some of the international bodies, as well as some industry-specific organizations. The ISO and CEN are non-commercial organizations, while Eurovent is an association of manufacturers. All work through specialized committees or working parties, which can sometimes take a very long time to produce a final version, especially if the 'published for general discussion' stage is a long one.

12.3 Relevant Standards

The prime aims of the inclusion of this chapter on standards relevant to the world of filter media are to show the complexity of the situation, and to highlight those

Table 12.1 Standards producing organizations

International	ISO	International Organization for Standards
	CEN	Comité Européen des Normalisations ^a
	EUROVENT	European Committee of Air Handling & Refrigerating Equipment Manufacturers ^b
British	BSI	British Standards Institution
	BW	British Water
German	DIN	German Institute for Standardization
	VDI	German Institute for Engineers
French	AFNOR	French Association for Standardization
Italian	UNI	Italian Institute for Standardization
American	ANSI	American National Standards Institute
	ASTM	American Society of Testing and Materials
	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
	AIHA	American Industrial Hygiene Association
	DOE/NRC	Department of Energy/Nuclear Regulatory Commission
	INDA	Association of the Nonwoven Fabrics Industry
	NIOSH	National Institute for Occupational Safety and Health
	NIST	National Institute of Standards and Technology
SAE	Society of Automotive Engineers	

^a CEN has as its national members the national standards organizations of the EU and EFTA countries, plus Czech Republic and Malta.

^b Full name is EUROVENT-Cecomaf.

of key interest. The list of standards that follows will also serve as an index to most of the references to standards in earlier chapters of this Handbook.

The standards cover:

- the mechanical testing of the materials used for filter media as to strength;
- the determination of particular filtration characteristics, such as pore size or permeability, of filter media;
- the testing of filtration efficiency (i.e. particle retention or penetration), including the definition of test dusts or aerosols, and methods for their characterization; this is done for filters for liquids and gases, and for particular applications, such as respirators, or lube oil filters.

The ways in which standards are developed for liquid systems – engine fluids and drinking water – has been well described by Peuchot, based on his work at IFTS, and for several standards bodies^(1,2). The world of air filtration standards has been reviewed by another international expert, Gustavsson, from his position as a manufacturer and academic^(3,4). Both are concerned to highlight changes in standards.

There is, of course, much overlap among standards published by different bodies, national and international. Gustavsson⁽³⁾ illustrates the relationships between the ASHRAE standards 52.1 and 52.2, and the European EN779 and EUROVENT standards. Thus ASHRAE 52.1 became the US national standard, and was adopted as EUROVENT 4/5, and then as EN 779. These were developed into EUROVENT 4/9, and the new version of EN 779 (prEN 779), and similar developments led to ASHRAE 52.2 – a good review of the derivation of the latter can also be found in the paper by Hanley *et al.*⁽⁵⁾.

Perhaps because of the long gestation time for a new standard, manufacturers can move into a perceived gap, as has Hy-Pro with its Dynamic Filter Efficiency method of testing⁽⁶⁾, which it claims to be an improvement on even the latest form of multipass test.

Much of the testing of filters and filter media is based upon the selection and definition of good test dusts, and some of the earliest relevant standards were involved in just such a definition. Better and better definition seems possible as shown by Bensch⁽⁷⁾ in a review of the impact of modern ISO standards on hydraulic and lubricating fluids.

12.3.1 National standards

A list of all the standards of possible relevance to filter media, including material testing and filtration characteristic determination, would be a vast undertaking, and of no real value to this Handbook. The following sections note the key standards for the British national body, and for one or two other national organizations, including the major international standards.

Tables 12.2 and 12.3 list the British standards covered in earlier chapters of this Handbook, and others of direct relevance, including both those particular to the BSI, and those with direct international equivalence. Table 12.2 has the

Table 12.2 British standards for filter media

Number	Title or comment
BS 1701:1970	Replaced by BS 7226:1989, and in turn by BS ISO 5011
BS 1747-2:1969	Methods for the measurement of air pollution. Determination of concentration of suspended matter
BS 1752:1983 (ISO 4793:1980)	Specification for laboratory sintered or fritted filters, including porosity grading
BS 2576:1986	Replaced by BS EN ISO 13934-1
BS 2831	Replaced by BS 6540
BS 3137:1972	Methods for determining the bursting strength of paper and board
BS 3321:1986	Method for the measurement of the equivalent pore size of fabrics (bubble point method)
BS 3356:1990	Method for determination of bending length and flexural rigidity of fabrics
BS 3406-9:1997	Method for the determination of particle size distribution. Recommendation for the filter blockage method (mesh obscuration)
BS 3748:1992 (ISO 2493:1992)	Method for determination of resistance to bending of paper and board
BS 3928:1969	Method for the sodium flame test for air filters (other than air supply to internal combustion engines and compressors)
BS 4400:1969	Method for sodium chloride particulate test for respiratory filters
BS 4415-1:1992 (ISO 1924-1:1992)	Determination of the tensile properties of paper and board. Constant loading rate method. Replaced by BS EN ISO 1924-2:1995
BS 4552-1:1979	Fuel filters, strainers and sedimenters for compression-ignition engines. Methods of test
BS 4555:1970	Replaced by BS 7355
BS 4768:1972	Replaced by BS EN ISO 13938-1 and 13938-2
BS 4836:1972	Replaced by BS 7403
BS 5295-1 and 2	Replaced by BS EN ISO 14644-1, -2, and -4
BS 5295-3:1989	Environmental cleanliness in enclosed spaces. Guide to operational procedures and disciplines applicable to clean rooms and clean air devices. (See also BS EN ISO 14644-1, -2 and -4)
BS 5540 Part 2:1992 (ISO 4402:1991)	Replaced by BS ISO 4406, 11171
BS 5600 Part 3 (ISO 4003:1997)	Replaced by BS EN ISO 24003:1993
BS 5636:1990	Method for determination of permeability of fabrics to air. Replaced by BS EN ISO 9237:1995
BS 6275-1:1982 (ISO 4572:1981)	Hydraulic fluid power filter elements. Method of evaluating filtration performance (multipass method). Replaced by BS ISO 2941, 2942, 2943, 3723, 3724, 16889
BS 6277:1982 (ISO 3968:1981)	Replaced by BS ISO 3968:2001
BS 6347-8:1993 (ISO 789-8:1991)	Performance assessment of agricultural tractors. Method of testing engine air cleaners
BS 6410:1991	Methods of test for filter papers
BS 6540-1:1985	Replaced by BS EN 779:1993
BS 6851:1987 (ISO 7744:1986)	Method for preparing a statement of requirements for hydraulic power filters
BS 6912-22-2:1996 (ISO 10263-2:1994)	Safety of earth moving machinery. Operator enclosure environment. Air filter test
BS 7355:1990	Replaced by BS EN 136:1998 and 143:2000
BS 7403-1:1998 (ISO 4548-1:1997)	Full-flow lubricating oil filters for internal combustion engines. Methods of test for differential pressure/flow characteristics

BS 7403-3:1998 (ISO 4548-3:1997)	Full-flow lubricating oil filters for internal combustion engines. Methods of test for resistance to high differential pressures and to elevated temperatures
BS 7403-4:1998 (ISO 4548-4:1997)	Full-flow lubricating oil filters for internal combustion engines. Methods of test for initial particle retention efficiency, life and cumulative efficiency (gravimetric method)
BS 7403-6:1991 (ISO 4548-6:1985)	Full-flow lubricating oil filters for internal combustion engines. Methods of test for static burst pressure
BS 7403-11:1998 (ISO 4548-11:1997)	Full-flow lubricating oil filters for internal combustion engines. Methods of test for self-cleaning filters
BS 7403-12:2000 (ISO 4548-12:2000)	Full-flow lubricating oil filters for internal combustion engines. Filtration efficiency using particle counting, and contaminant retention capability
BS 7591-1:1992	Porosity and pore size distribution of materials. Method of evaluation by mercury porosimetry
BS 7591-2:1992	Porosity and pore size distribution of materials. Method of evaluation by gas adsorption
BS 7591-4:1993	Porosity and pore size distribution of materials. Method of evaluation by liquid expulsion
BS 7881:1997	Method of test for petrol filters

Table 12.3 British/international standards

Number	Title or comment
BS ISO 2941:1974	Hydraulic fluid power. Filter elements. Verification of collapse/burst resistance
BS ISO 2942:1994	Hydraulic fluid power. Filter elements. Verification of fabrication integrity and determination of the first bubble point
BS ISO 2943:1998	Hydraulic fluid power. Filter elements. Verification of material compatibility with fluids
BS ISO 3723:1976	Hydraulic fluid power. Filter elements. Method for end load test
BS ISO 3724:1976	Hydraulic fluid power. Filter elements. Verification of flow fatigue characteristics
BS ISO 3968:2001	Hydraulic fluid power. Filters. Evaluation of differential pressure versus flow characteristics
BS ISO 4020:2001	Road vehicles. Fuel filters for diesel engines. Test method
BS ISO 4406:1999	Hydraulic fluid power. Fluids. Method for coding the level of contamination by solid particles
BS ISO 5011:2000	Inlet air cleaning equipment for internal combustion engines and compressors. Performance testing
BS ISO 5782-1:1997	Pneumatic fluid power. Compressed air filters. Main characteristics to be included in supplier's literature and product marking requirements
BS ISO 5782-1:1997	Pneumatic fluid power. Compressed air filters. Test methods to determine the main characteristics to be included in supplier's literature
BS ISO 11170:1995	Hydraulic fluid power. Filter elements. Procedure for verifying performance characteristics
BS ISO 11171:1999	Hydraulic fluid power. Fluids. Calibration of automatic particle counters for liquids
BS ISO 11841-1:2000	Road vehicles and internal combustion engines. Filter vocabulary. Definitions of filters and filter components
BS ISO 11841-2:2000	Road vehicles and internal combustion engines. Filter vocabulary. Definitions of characteristics of filters and their components
BS ISO 11943:1999	Hydraulic fluid power. On-line automatic particle-counting systems for liquids. Methods of calibration and validation

Table 12.3 (continued)

Number	Title or comment
BS ISO 12103-1:1997	Road vehicles. Test dust for filter evaluation. Arizona test dust
BS ISO 12103-2:1997	Road vehicles. Test dust for filter evaluation. Aluminium oxide test dust
BS ISO 14269-4:1997	Tractors and self-propelled machines for agriculture and forestry. Operator enclosure environment. Air filter test method
BS ISO 16889:1999	Hydraulic fluid power. Filters. Multipass method for evaluating filtration performance of a filter element
BS EN 136:1998	Respiratory protective devices. Full face masks. Requirements, testing, marking
BS EN 141:2000	Respiratory protective devices. Gas filters and combined filters. Requirements, testing, marking
BS EN 143:2000	Respiratory protective devices. Particle filters. Requirements, testing, marking
BS EN 149:2000	Respiratory protective devices. Filtering half-masks to protect against particles. Requirements, testing, marking
BS EN 405:2000	Respiratory protective devices. Valved filtering half-masks to protect against gases or gases and particles. Requirements, testing, marking
BS EN 779:1993	Particulate air filters for general ventilation. Requirements, testing, marking
BS EN 1822-1:1998	High-efficiency air filters (HEPA and ULPA). Part 1: Classification, performance testing, marking
BS EN 1822-2:1998	High-efficiency air filters (HEPA and ULPA). Part 2: Aerosol production, measuring equipment, particle counting statistics
BS EN 1822-3:1998	High-efficiency air filters (HEPA and ULPA). Part 3: Classification, performance testing, marking
BS EN 1822-4:1998	High-efficiency air filters (HEPA and ULPA). Part 4: Testing flat sheet filter media
BS EN 1822-5:1998	High-efficiency air filters (HEPA and ULPA). Part 5: Determining the efficiency of a filter element
BS EN 1827:2000	Respiratory protective devices. Half-masks without inhalation valves and with separable filters to protect against gases or gases and particles or particles only. Requirements, testing, marking
BS EN 12083:2000	Respiratory protective devices. Filters with breathing hoses (non-mask mounted filters). Particle filters, gas filters and combined filters. Requirements, testing, marking
BS EN 12341:1999	Air quality. Determination of the PM ₁₀ fraction of suspended particle matter. Reference method and field test procedure to demonstrate reference equivalence of measurement method
BS EN 12901:1999	Products used for treatment of water intended for human consumption. Inorganic supporting and filtering materials. Definitions
BS EN 12902:1999	Products used for treatment of water intended for human consumption. Inorganic supporting and filtering materials. Methods of test
BS EN 12941:2000	Respiratory protective devices. Powered filtering devices incorporating a helmet or a hood. Requirements, testing, marking
BS EN 12942:2000	Respiratory protective devices. Power assisted filtration devices incorporating full face masks, half-masks or quarter-masks. Requirements, testing, marking
BS EN 13274-1:2001	Respiratory protective devices. Methods of test. Determination of inward leakage and total inward leakage
BS EN 13274-2:2001	Respiratory protective devices. Methods of test. Practical performance tests
BS EN 13274-3:2001	Respiratory protective devices. Methods of test. Determination of breathing resistance
BS EN 13274-4:2001	Respiratory protective devices. Methods of test. Flame tests
BS EN 13274-5:2001	Respiratory protective devices. Methods of test. Climatic conditions
BS EN 13328-1:2001	Breathing system filters for anaesthetic and respiratory use. Salt test method to assess filtration performance

Table 12.3 (continued)

Number	Title or comment
BS EN ISO 1924-2:1995	Paper and board. Determination of tensile properties. Constant rate of elongation method
BS EN ISO 9237:1995	Textiles. Determination of the permeability of fabrics to air
BS EN ISO 13934-1:1999	Textiles. Tensile properties of fabrics. Determination of maximum force and elongation at maximum force using the strip method
BS EN ISO 13934-2:1999	Textiles. Tensile properties of fabrics. Determination of maximum force using the grab method
BS EN ISO 13938-1:1999	Textiles. Bursting properties of fabrics. Hydraulic method for determination of bursting strength and bursting distension
BS EN ISO 13938-2:1999	Textiles. Bursting properties of fabrics. Pneumatic method for determination of bursting strength and bursting distension
BS EN ISO 14644-1:1999	Cleanrooms and associated controlled environments. Classification of air cleanliness
BS EN ISO 14644-2:2000	Cleanrooms and associated controlled environments. Specifications for testing and monitoring to prove continued compliance with ISO 14644-1
BS EN ISO 14644-4:2001	Cleanrooms and associated controlled environments. Design, construction and start-up
BS EN ISO 24003:1993	Permeable sintered metal materials. Determination of bubble test pore size

Table 12.4 Other national standards

Country/number	Title or comment
<i>USA</i>	
ASHRAE 52.1-1992	Gravimetric and dust-spot procedures for testing air-cleaning devices used in general ventilation for removing particulate matter
ASHRAE 52.2-1999	Method of testing general ventilation air-cleaning devices for removal efficiency by particle size
<i>Germany</i>	
VDI 3926:1994	Guideline for the characterization and evaluation of cleanable filter media with respect to their long-term filtration behaviour

basic BSI standards, quoting ISO equivalents where they exist. Table 12.3 having the combined national/international standards. The gradual integration of national, regional and international standards can be seen in both tables.

Other national standards are shown in Table 12.4, covering the two key ASHRAE documents on dust removal filter testing, and the VDI guideline on cleanable filter media.

12.3.2 Other international standards

Most of the key CEN and ISO standards have already been listed in Table 12.3, under combined BSI/CEN/ISO numbers – the reader will have to consult Tables 12.2 and 12.3, for example, for all ISO standards of relevance. Table 12.5 lists some more international documents not already covered, including the important EUROVENT standards.

Table 12.5 Other international standards

Organization	Title or comment
<i>Eurovent</i>	
4/4:1984	Sodium chloride aerosol test for filters using flame photometric technique
4/5:1992	Method of testing air filters used in general ventilation
4/8:1985	<i>In situ</i> leak testing of high-efficiency filters in clean spaces
4/9:1996	Method of testing air filters used in general ventilation for determination of fractional efficiency
4/10:1996	<i>In situ</i> determination of fractional efficiency of general ventilation filters
<i>CEN</i>	
prEN 779:2001	Particulate air filters for general ventilation. Determination of the filtration performance
prEN 13443-1	Water conditioning equipment inside buildings. Mechanical filters. Part 1: Particle rating 80–150 µm. Requirements for performance and safety, testing
prEN 13443-2	Water conditioning equipment inside buildings. Mechanical filters. Part 2: Particle rating 1 to <80 µm. Requirements for performance and safety, testing
prEN 13779	Ventilation for non-residential buildings. Performance requirements for ventilation and air conditioning equipment

Also in Table 12.5 are some CEN standards under review, including the important revised form of EN 779, which aims to introduce a new standard based upon a filter's fractional particle efficiency, covering a lifetime's behaviour, not just as-new performance.

12.4 References

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7. L Bensch (1999) 'Impact of changes to ISO standards on filter performance and fluid cleanliness', *Fluid Power Journal*, Sept./Oct.