

American Water Works Association

ANSI/AWWA B100-96

(Revision of ANSI/AWWA B100-89)



AWWA STANDARD
FOR
FILTERING MATERIAL



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AMERICAN WATER WORKS ASSOCIATION

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Foreword

This foreword is for information only and is not a part of AWWA B100.

I. Introduction

I.A. *Background.* The purpose of ANSI/AWWA B100 is to provide purchasers with a standard for the purchase and installation of filtration materials.

A wealth of information on innovations in filter design is available from various sources, including *Journal AWWA* and *Water Treatment Plant Design*.^{*} These sources include design parameters for filters using single and multiple media. As a result, ANSI/AWWA B100 makes reference to filter design only as the design relates to the filtering materials used (see Appendix A). ANSI/AWWA B604 Standard for Granular Activated Carbon should be consulted when using granular activated carbon (GAC) as a filter medium, because GAC is not specifically covered in B100. NOTE: ANSI/AWWA Standard B604-96 covers GAC as a filter media.

I.B. *History.* The AWWA Standard for Filtering Material was approved as tentative by the AWWA Board of Directors on Nov. 15, 1948, and as standard on Jan. 16, 1950. Revisions were approved on June 2, 1953, Jan. 31, 1972, June 20, 1980, and Jan. 29, 1989. The original standard was approved and promulgated in the course of activities of the Water Purification Division and under jurisdiction of the Committee on Water Works Practice. This edition was approved by the AWWA Board of Directors on Feb. 4, 1996.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for all direct and indirect drinking water additives. Other members of the original consortium included the American Water Works Association Research Foundation (AWWARF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.[†] Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.
2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF, ANSI[‡]/NSF[§] 60, Drinking Water Treatment Chemicals—Health Effects, and ANSI/NSF 61, Drinking Water System Components—Health Effects.

^{*}*Water Treatment Plant Design*, AWWA, ASCE, and CSSE, Denver, Colo. (1989).

[†]Persons in Canada, Mexico, and non-North American countries should contact the appropriate authority having jurisdiction.

[‡]American National Standards Institute, 11 W. 42nd St., New York, NY 10036.

[§]NSF International, 3475 Plymouth Rd., Ann Arbor, MI 48106.

4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,^{*} and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with ANSI/NSF 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Appendix A, "Toxicology Review and Evaluation Procedures," to ANSI/NSF 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Appendix A procedures may not always be identical, depending on the certifier.

AWWA B100 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements including applicable standards.
2. Determine the status of certifications by all parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues

II.A. *Source of Supply.* Filtering materials, such as silica sand, high-density sand, granular activated carbon, or anthracite, as well as support gravel, should be obtained from sources that are expressly qualified to produce and furnish these materials for water treatment plants.

II.B. *Filter Media.* Filter media is the portion of the filter bed that removes particulate matter from the water during the filtration process. This standard covers anthracite, silica sand, and high-density sand. Properties of granular activated carbon when used as a filter medium will be covered in a pending revision to ANSI/AWWA B604, Standard for Granular Activated Carbon. Properties of media used in precoat filters (such as diatomaceous earth) can be found in ANSI/AWWA Standard B101, Standard for Precoat Filter Media.

Sand or anthracite filter media used in a wide range of bed depths and particle sizes have produced satisfactory results. Selection of the bed depth or particle size to be used in any particular filter is the responsibility of the designer and should be executed with careful consideration of raw water conditions and plant pretreatment facilities.

In general, for a given pretreatment of raw water at a given filtration rate, coarse media will permit longer filter runs between washings than allowed by fine media. With good pretreatment facilities and close technical control, coarse media will yield water of satisfactory quality. With all other conditions fixed, removal of particulate matter is a function of both media size and filter bed depth, and removal generally improves with greater filter depth or with smaller media size, or both.

Dual- or multiple-media filters have been used instead of single-medium filters in many water treatment applications. The dual or multiple media are selected to

^{*}Both publications available from National Academy of Sciences, 2102 Constitution Ave. N.W., Washington, DC 20418.

maintain coarse media in the upper portion of the bed and fine media in the lower portion of the bed. The coarse-to-fine grading tends to combine longer filter runs, characteristic of coarse media, with superior filtration, characteristic of fine media, for improved overall performance. Proper selections of particle size range and specific gravity for the different layers of media are necessary to maintain the coarse-to-fine gradation during filtration and after repeated backwashing.

GAC is suitable for use as a filter medium either alone or as a dual media with sand. Long-term experience indicates that GAC performs effectively in a dual role as a filter medium and as an adsorber for control of taste and odors. A planned revision of ANSI/AWWA B604 will provide information on the use of GAC as a filter medium including its properties, sampling, testing, shipping, placement, and preparation for service.

Where anthracite is used in dual- or multiple-media filters, the size of the anthracite depends on the size and specific gravity of the sand or other material used beneath the anthracite. If the anthracite grains are too small, excessive losses will be incurred during the minimum backwash required to clean the sand effectively. If the anthracite grains are too large, excessive mixing of the two materials will occur at the interface.

High-specific-gravity (high-density) filter media consisting of garnet, ilmenite, hematite, magnetite, or associated minerals of those ores are used by some utilities in an attempt to remove more suspended solids at higher filtration rates. This small, high-density media remains as a layer under the silica sand as a result of particle size and specific gravity differences in the same way that silica sand remains separated from overlaid coal in a dual-media filter.

Garnet refers to several different minerals (mostly almandite and andradite) that are silicates of iron, aluminum, and calcium mixtures. However, garnet could also be grossularite, spessartite, and uvarovite, the latter being a chromium mineral. Ilmenite is an iron titanium mineral, which invariably is associated with hematite and magnetite, both iron oxides.

Particle size distribution. There are two methods of classifying particle size distribution; either method may be used. The first method assigns limiting sizes to stated percentages by weight. For example, 10 percent, by weight, of the total lot of filter media shall measure between X mm and Y mm, 60 percent shall measure between A mm and B mm, and 90 percent shall measure between S mm and T mm. Because sieves will not separate the media into fractions exactly equal to 10 percent, 60 percent, and 90 percent of the total weight, the sizes corresponding to the percentages must be interpolated from a plot of the percentage of sample passing each sieve against the separation size of that sieve. The plot should be made on log-probability paper or semilog paper.

The second method of classifying particle size distribution defines the percentage of media that shall be finer than a stated particle size. For example, the percentage of media finer than 0.4 mm shall be between X percent and Y percent of the total lot of filter media. By fixing percentages X and Y that correspond to the separation sizes of standard sieves, the results of a sieve analysis can be used directly without plotting.

In addition to classifying particle size distribution as described above, media gradation may also be described in terms of effective size and uniformity coefficient as defined in Sec. 3.3 and Sec. 3.8 of ANSI/AWWA B100, respectively. In 1892, Hazen found that the permeability of sand in a loose state correlates with the effective size

and uniformity coefficient, and subsequent practice has indicated that these terms are useful for characterizing filter media gradations.

When specifying filter media size, the purchaser should use either (1) the effective size and uniformity coefficient or (2) one of the two methods of classifying particle size distribution previously discussed. Attempting to specify media size by both techniques may result in specifying a particle size distribution that cannot be attained by media producers.

Anthracite sizes. Effective sizes of anthracite generally range from a low of 0.6 mm to a high of 1.6 mm, and uniformity coefficients are generally 1.7 or lower.

Silica sand sizes. Effective sizes of silica sand generally range from a low of 0.35 mm to a high of 0.65 mm, and uniformity coefficients are generally 1.7 or lower.

High-density sand sizes. Effective sizes for high-density sand generally range from a low of 0.18 mm to a high of 0.60 mm, and uniformity coefficients are generally 2.2 or lower.

II.C. Filter Gravel. If the openings in the underdrain system are larger than the filter medium, a system of supporting layers of gravel is required to prevent the filter medium from entering and blocking the underdrain system and to help distribute backwash water evenly. The size and depth of the gravel layers must be selected to achieve both objectives and to ensure that the gravel will not be displaced by the rising wash water.

The following guidelines can be used to select the sizes and depths of gravel layers for a conventional gravel system.

The grains of each layer should be as uniform in size as possible, with the ratio of maximum particle size to minimum particle size not greater than 2. The minimum particle size of the top layer of fine gravel should be four to four-and-a-half times the effective size of the finest filter medium to be retained. From layer to layer, the ratio of maximum particle size of the coarser layer should not be greater than four times the minimum particle size of the finer layer. The gravel of the bottom layer should be coarse enough to prevent its displacement by the jets of air or water emerging from the orifices of the underdrain system. The minimum particle size of the lowest layer should be two to three times the size of the orifices.

The thickness of each layer of gravel should be at least three times the maximum particle size of the gravel in the layer, but not less than 3 in. in any case. In the case of irregular underdrain bottoms, such as pipe laterals, the lowest layer should completely surround or cover the underdrain to provide a uniform upper gravel surface on which the next gravel layer is placed.

Many combinations of gravel size and layer thickness have been used. Table F.1 describes two typical series of gravel layers that generally meet the aforementioned guidelines. The top layer gradation is controlled by the fine filter-medium size to be retained, and the bottom layer gradation is controlled by the underdrain orifice sizes. The examples use commercially available gravel sizes indicated by their ASTM E11 sieve designations.

In some designs, a high-density filter gravel is used as a replacement for, or in addition to, the top layer in the gravel system to give added stability to the gravel system during backwashing. The range in size and thickness of the high-density filter gravel layer must be closely coordinated with the other gravel layers and the overlying media. Generally, at least 92 percent by weight shall pass through a No. 4 sieve and no more than 8 percent by dry weight shall pass through a No. 16 sieve. The layer thickness normally ranges from 2 in. to 4 in.

Table F.1 Gravel layers for two sizes of fine media and two sizes of underdrain orifices*

Gravel Layers From Top to Bottom	Fine Media Effective Size 0.40 mm–0.50 mm Underdrain Orifice Size 6.35 mm (0.25 in.)		Fine Media Effective Size 0.50 mm–0.60 mm Underdrain Orifice Size 12.7 mm (0.5 in.)	
	Gradation of Gravel†	Thickness of Layer	Graduation	Thickness
1st‡	3.35 mm–1.70 mm (No. 6–No. 12)	76 mm (3 in.)	4.75 mm–2.0 mm (No. 4–No.10)§	76 mm (3 in.)
2nd	6.3 mm–3.35 mm (¼ in.–No. 6)	76 mm (3 in.)	9.5 mm–4.75 mm (⅜ in.–No. 4)	76 mm (3 in.)
3rd	12.5 mm–6.3 mm (½ in.–¼ in.)	76 mm (3 in.)	19.0 mm–9.5 mm (¾ in.–⅜ in.)	76 mm (3 in.)
4th	25.0 mm–16.0 mm (1 in.–⅝ in.)**	76 mm–102 mm (3 in.–4 in.)	37.5 mm–19.0 mm (1½ in.–¾ in.)	76 mm–127 mm (3 in.–5 in.)
5th	None		63 mm–37.5 mm (2½ in.–1½ in.)	127 mm–203 mm (5 in.–8 in.)

*These examples do not apply when air scour is delivered through the gravel layers.

†Standard sieve sizes from ASTM E11 (Standard designation and alternative designation. See Table B.1, column 1, subcolumns 1 and 2.)

‡This layer may be replaced or supplemented by high-density gravel. Gradation and thickness of layer must be coordinated with the other gravel layers and the filter media.

§No. 4–No. 8 preferred, if available.

**¾-in. to ½-in. size may be considered as an alternate.

For special applications, high-density gravels are available for all layers. These applications are not described in this standard. Special provisions are required when air scour delivered through the gravel layers is used to assist the backwashing. These special provisions are not described in this standard.

II.D. Acid Solubility. An acid-solubility test is included in this standard to provide a means of measuring acid-soluble minerals or other impurities that may be present in the filter material. The limits for acid solubility given in this standard are based on tests of filter materials with proven performances in a wide range of water treatment applications. Acid-solubility limits are necessary to ensure against substantial quantities of detrimental minerals or other substances in the filter material and to ensure against substantial solution of filter material in acidic waters or during an acid cleaning. In many cases, the principal acid-soluble impurity in filter silica sand and gravel is calcium carbonate (limestone).

II.E. Anthracite Quality Tests. Based on some utility experiences of high anthracite loss during use in filters and the problem with Mohs' scale of hardness not accurately defining the hardness of coal, other abrasion tests were investigated. Samples of anthracite (new and used, soft and hard, good and poor performing) were subjected to a battery of tests for abrasion (Mohs' scale of hardness, paint shaker friability, and Hardgroves' Grindability Index [HGI]). These data were correlated to other characteristics (volatiles, ash, carbon content). The committee also arranged for presentations by a major filter equipment supplier, who extensively studied various

sources of anthracite, and an anthracite expert, who has significant experience specifying anthracite for other industries. Both outside experts concluded that HGI and other characteristics were also valuable in defining a high-quality coal.

Despite the consensus on the value of these new parameters, the committee could not agree to change the standard at this time because more data is needed. The committee was also concerned that many current coal suppliers might not be able to meet the new standard and, therefore, supply to the entire water industry might be jeopardized. More data may allow precise limits for these new parameters to be set. Therefore, discussion of these new anthracite characteristics will be confined to the foreword only. Users of anthracite are encouraged to request data on these new characteristics from their suppliers beginning immediately. These data will be crucial to the preparation of the next revision of this standard. Following is a list of suggested additional tests: HGI, percent volatiles (dry ash-free), ash percent (dry), carbon percent, and washability characteristics (percent material with specific gravity below 1.4, and percent material with specific gravity above 1.95).

These new characteristics can be tested by using the following standards:

ASTM D409—Standard Test Method for Grindability of Coal by the Hardgrove-Machine Method.

ASTM D3174—Standard Test Method for Ash in the Analysis Sample of Coal and Coke from Coal.

ASTM D3175—Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke.

ASTM D4371—Standard Test Method for Determining the Washability Characteristics of Coal.

II.F. Bulk Shipment. The issue of protecting media from contamination during shipment has been addressed in this revision.

Bulk shipment is not recommended; however, when trucks or railcars are specified for hauling a bulk shipment of filter material, it is recommended that an impermeable plastic liner be used because these trucks or railcars may be contaminated from hauling previous bulk material.

Vibration during transit will result in media separation with the coarser material migrating toward the top. If one compartment of the bulk shipment is divided between two or more filters or filter halves, the filter media is likely to have different size gradations and consequently perform differently. Therefore, if bulk shipment is allowed, the container should be required to be compartmentalized so that each compartment fills no more than one filter cell. If it is specified, representative media samples for analysis can be obtained at the point of production or loading. If the purchaser requires sampling at the point of installation, this requirement should be stated in the specifications.

II.G. Media Records. Users are encouraged to maintain records of the physical characteristics and chemical composition of all media installed in filters. For limits on undesirable impurities, refer to NSF Standard No. 61 and Section I.C in the foreword.

III. Use of This Standard. AWWA has no responsibility for the suitability or compatibility of the provisions of this standard to any intended application by any user. Accordingly, each user of this standard is responsible for determining that the standard's provisions are suitable for and compatible with that user's intended application.

III.A. Purchaser Options and Alternatives. The following items should be covered in the purchaser's specifications: