American Water Works Association

ANSI/AWWA B100-96

(Revision of ANSI/AWWA B100-89)

AWWA STANDARD

FOR

FILTERING MATERIAL

AMERICAN NATIONAL STANDARD

Return to List of Standards

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AMERICAN WATER WORKS ASSOCIATION

6666 West Quincy Avenue, Denver, Colorado 80235

AWWA Standard

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

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:

1. Standard used—that is, ANSI/AWWA B100, Standard for Filtering Material, of latest revision.

2. Method of measurement and payment, and whether this project covers the furnishing of filter materials only, or the furnishing and placement of the materials and preparation for service.

3. Method of disinfecting (Sec. 4.5.3) and who will perform the disinfection procedure.

4. Whether an affidavit of compliance is required or whether the purchaser will select a representative to inspect the supply for compliance with this standard.

5. Whether representative approval samples are required before shipment (Sec. 5.1) or are in place (Sec. 4.5.2.4).

6. Sizes, types, and characteristics of filter materials required and quantities of each (Sec. II.B, Sec. II.C, Sec. 4.1.1, and Sec. 4.1.2). If the supplier, manufacturer, or constructor is to be held responsible for meeting a specification regarding particle size for media in place, the specifications should require that the supplier, manufacturer, or constructor supervise the transportation, handling, on-site storage, placement, and field preparation of the media for sampling. This includes all backwashing of media prior to sampling.

7. Method of placing the material, if there is a preference (Sec. 4.4.2).

8. Method of checking elevation of top surface of each layer, if there is a preference (Sec. 4.4.3).

III.B. *Modification to Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided in the purchaser's specifications.

IV. Major Revisions. Major changes made to the standard in this revision include the following:

1. The format has been changed to AWWA standard style.

2. The acceptance clause (Sec. I.C) and definitions (Sec. 3) have been revised to approved wording.

3. Discussion of a potentially new anthracite standard is included in the foreword.

4. Addition of reference to a planned revision of ANSI/AWWA B604 for use of GAC as filter medium.

5. Addition of high-density sand and gravel media.

6. Revision to delivery and bulk shipment requirements.

7. Adoption of an alternative test for large-aggregate specific gravity.

8. Addition of in-place media sampling.

9. Substitution of ASTM C128 for ASTM C188 as the standard specific gravity test of fine aggregates.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Standards and Materials Development Department, (303) 794-7711 ext. 6283, FAX (303) 795-1440, or write to the department at 6666 W. Quincy Ave., Denver, Colorado 80235.

American Water Works Association

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(Revision of ANSI/AWWA B100-89)

AWWA STANDARD FOR

FILTERING MATERIAL

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard covers gravel, high-density gravel, silica sand, high-density media, anthracite filter materials, and the placement of the materials in filters for water supply service application. A planned revision to ANSI/AWWA B604 Standard for Granular Activated Carbon will address the use of GAC as a filter medium and as an adsorbent.

Sec. 1.2 Purpose

The purpose of this standard is to provide purchasers with a standard for purchasing and installing filtration materials; it is not intended as a guide for filter design.

Sec. 1.3 Application

This standard can be referenced in specifications for purchasing and receiving filtering material and can be used as a guide for testing the physical and chemical properties of filtering material samples. The stipulations of this standard apply when this document has been referenced and only to filtering materials used in the treatment of drinking water supplies.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, these documents form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

ASTM[*] C40—Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

ASTM C117—Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.

ASTM C123—Standard Test Method for Lightweight Pieces in Aggregate.

ASTM C127—Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

ASTM C128—Standard Test Method for Specific Gravity and Absorption of Fine Aggregate.

ASTM C136—Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

ASTM C702—Standard Practice for Reducing Samples of Aggregate to Testing Size.

ASTM D75—Standard Practice for Sampling Aggregates.

ASTM E11—Standard Specification for Wire Cloth and Sieves for Testing Purposes.

MIL-STD-105D—Sampling Procedures for Inspection by Attributes.

ANSI/AWWA C653—Standard for Disinfection of Water Treatment Plants.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Bag:* A plastic, paper, or woven container generally containing approximately 1 ft^3 or less of filter material.
2. *Constructor:* The party that furnishes the work and materials for placement or installation.
3. *Effective size:* The size opening that will just pass 10 percent (by dry weight) of a representative sample of the filter material; that is, if the size distribution of the particles is such that 10 percent (by dry weight) of a sample is finer than 0.45 mm, the filter material has an effective size of 0.45 mm.
4. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.
5. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.
6. *Semibulk container:* A large plastic or woven bulk container generally containing approximately 1 ton or more of filter material. It is commonly referred to as a sack.
7. *Supplier:* The party that supplies materials or services. A supplier may or may not be the manufacturer.
8. *Uniformity coefficient:* A ratio calculated as the size opening that will just pass 60 percent (by dry weight) of a representative sample of the filter material divided by the size opening that will just pass 10 percent (by dry weight) of the same sample.

[*]American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

SECTION 4: REQUIREMENTS

Sec. 4.1 Physical Requirements

4.1.1 *Filter media.* Filter media of anthracite, silica sand, and high-density sand shall conform to the following requirements.

4.1.1.1 Anthracite.

1. Filter anthracite shall consist of hard, durable anthracite coal particles of various sizes. Blending of non-anthracite material to meet any portion of this standard is not acceptable.
2. The anthracite shall have specific gravity, Mohs' scale of hardness, and acid solubility levels as indicated in Table 1.
3. The anthracite shall be visibly free of shale, clay, and other extraneous debris.

4.1.1.2 Silica sand.

1. Silica sand shall consist of hard, durable, and dense grains of predominantly siliceous material that will resist degradation during handling and use.
2. The silica sand shall have specific gravity and acid solubility levels as indicated in Table 1.
3. The silica sand shall be visibly free of clay, dust, and micaceous and organic matter.

4.1.1.3 High-density sand.

1. High-density sand shall consist of hard, durable, and dense grain garnet, ilmenite, hematite, magnetite, or associated minerals of those ores that will resist degradation during handling and use.
2. The high-density sand shall have specific gravity, Mohs' scale of hardness, and acid solubility levels as indicated in Table 1.
3. The high-density sand shall be visibly free of clay, dust, and micaceous and organic matter.

NOTE: Testing for clay, dust, and micaceous and organic matter is normally not necessary, but if deleterious materials are noticeable, the media shall be within the following limits: (1) a maximum of 2 percent minus No. 200 (0.074 mm) material by washing, as determined by ASTM C117; and (2) a color not darker than the standard color in ASTM C40 for organic impurities in fine aggregate.

4.1.1.4 Media size.

1. The media size is commonly specified in terms of effective size (ES) and uniformity coefficient (UC) or in terms of particle size range. Only one of the following shall be used:

Table 1 Physical characteristics of filter media

Filter Media	Characteristics: Specific Gravity	Hardness (Mohs' Scale)	Acid Solubility %
Anthracite*	>1.4	>2.7	<5
Silica Sand	>2.5	NA	<5
High-Density Sand	>3.8	>5	<5

*See foreword for suggestions on additional anthracite tests.

a. The effective size, as defined in Sec. 3.3, and the uniformity coefficient, as described in Sec. 3.8, shall be as specified by the purchaser.

b. The particle size range, including allowable percentage, by weight, of undersize and oversize particles, shall be as specified by the purchaser. The size range shall state the 90 percent, 60 percent, and 10 percent sizes passing by dry weight, or other information pertinent to special applications.

4.1.2 *Filter gravel.* Filter gravel, including silica gravel and high-density filter gravel, shall meet the following requirements.

4.1.2.1 Silica gravel.

1. Silica gravel shall consist of coarse aggregate in which a high proportion of the particles are round or equidimensional in shape. It shall possess sufficient strength and hardness to resist degradation during handling and use, be substantially free of deleterious materials, and exceed the minimum specific gravity requirement.

2. Silica gravel shall have a saturated-surface-dry specific gravity of not less than 2.5, unless a higher minimum specific gravity requirement is specified to meet a design requirement for a particular layer or filter.

3. Not more than 25 percent, by dry weight, of the particles shall have more than one fractured face (Sec. 5.3.2).

4. Not more than 2 percent, by dry weight, of the particles shall be flat or elongated to the extent that the longest axis of a circumscribing rectangular prism exceeds five times the shortest axis (Sec. 5.3.2).

5. The silica gravel shall be visibly free of clay, shale, or organic impurities.

NOTE: Testing for clay, shale, or organic impurities is not normally necessary, but if deleterious materials are noticeable, the gravel shall be within the following limits: (1) a maximum of 1.0 percent minus No. 200 (0.074 mm) material by washing, as determined by ASTM C117; and (2) a maximum of 0.5 percent coal, lignite, and other organic impurities, such as roots or twigs, as determined by ASTM C123 for lightweight pieces in aggregate using a liquid with a 2.0 specific gravity.

4.1.2.2 High-density filter gravel.

1. High-density filter gravel shall be a coarse aggregate consisting of garnet, ilmenite, hematite, magnetite, or associated minerals of those ores in which a high proportion of the particles are either round or equidimensional in shape. It shall possess sufficient strength and hardness to resist degradation during handling and use, be substantially free of deleterious materials, and exceed the minimum density requirement.

2. High-density filter gravel shall have a specific gravity of not less than 3.8, meaning that at least 95 percent of the material shall have a specific gravity of 3.8 or higher.

3. Not more than 2 percent, by dry weight, of the particles shall be flat or elongated to the extent that the longest axis of a circumscribing rectangular prism exceeds five times the shortest axis (Sec. 5.3.2).

4. The high-density gravel shall be visibly free of clay, shale, or organic impurities.

4.1.2.3 Gravel size. Filter gravel shall be furnished in the particle size ranges stated in the purchaser's specification. For each size range of gravel specified, not more than 8 percent by dry weight shall be finer than the lowest designated size limit, and a minimum of 92 percent by dry weight shall be finer than the highest designated size limit.

4.1.2.4 Acid solubility. Acid solubility shall not exceed 5 percent for sizes smaller than No. 8 (2.36 mm), 17.5 percent for sizes larger than No. 8 (2.36 mm) but smaller than 25.4 mm (1 in.), and 25 percent for sizes 25.4 mm (1 in.) and larger. If gravels contain materials larger or smaller than the specified size, and if the total sample does not meet the specified solubility limit for the smaller material, the gravel shall be separated into two portions and the acid solubility of each portion must meet the appropriate designated percent solubility.

Sec. 4.2 Chemical Requirements

This standard has no applicable information for this section.

Sec. 4.3 Impurities

Refer to acceptance section (Sec. I.C) in the foreword.

Sec. 4.4 Placing Filter Materials

4.4.1 *Preparing filter cell.** Filter cells shall be prepared according to the following procedure.

4.4.1.1 Cleaning filter cells. Each filter cell shall be cleaned thoroughly before any filter materials are placed. Cleaning shall include the underdrain plenum, which may need to be vacuumed. Each cell shall be kept clean throughout placement operations.

4.4.1.2 Marking each layer. Before any materials are placed, the top elevation of each layer shall be marked by a level line on the inside of the filter cell.

4.4.1.3 Storing and handling materials. Filter materials shall be kept clean. If material cannot be placed immediately into the filter, the bulk materials shall be stored on a clean, hard, dry surface and covered at the water utility site to prevent contamination. Materials shipped in bags or semibulk containers shall be covered with a durable opaque material to block sunlight and to provide protection from weather. Bags and semibulk containers shall be stored on pallets or dunnage. Each size and type of filter material shall be stored separately. Materials shipped in bags or semibulk containers shall not be removed from the bags or semibulk containers before placement in the filter under any circumstance, except for sampling.

4.4.2 *Placing materials.*

4.4.2.1 Caution. The bottom layer of gravel shall be carefully placed to avoid damaging the filter underdrain system. For materials smaller than ½ in., workers shall not stand or walk directly on the filter material. They shall walk on boards or plywood that will support their weight without displacing the material. The same care should be taken when an air wash system is installed above the gravel.

4.4.2.2 Placing layers. Each layer shall be completed before the layer above it is started. Each layer of filter material shall be deposited in a uniform thickness. Care shall be exercised in placing each layer to avoid disturbing the integrity of the layer beneath. The top surface shall be screeded level.

4.4.2.3 Alternate method of placement. Bulk materials may be placed dry by using a chute or conveyor to discharge the materials onto a platform from which they may be distributed with a hand shovel. Alternatively, bulk materials may be placed hydraulically by pump or ejector.

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*In new filter construction, the placement of filter media should follow operational testing of the backwash system and assurance that the filter box is watertight. See Table 2 for maximum backwash rates.

For filter sand or anthracite placed using the wet method, the materials shall be added through the water and then backwashed for leveling. Pneumatic handling of anthracite is not recommended.

4.4.2.4 Placing material from bags or semibulk containers. When filter material is shipped in bags or semibulk containers and hydraulic placement is not used, the bags or semibulk containers shall be placed in the filter and the material distributed directly from them. (CAUTION: Do not disturb any layers already in place.) For the top media layer, only 90 percent of its intended depth should be added, then the initial backwashing shall proceed. Following this, the additional 10 percent or whatever is necessary to reach the finished elevation shall be added.

4.4.2.5 Layer elevation. The elevation of the top surface of each layer shall be checked by filling the filter with water to the level line previously marked on the inside of the filter cell.

4.4.2.6 Washing gravel layer. After all filter gravel is placed, and before any filter sand or anthracite is placed, the filter should be washed for 5 min at the maximum available rate, not to exceed 25 gpm/ft^2 of filter area. Care shall be taken not to disturb the graded gravel, especially if air is present in the underdrain. Any gravel that becomes disturbed by the wash shall be removed and replaced with clean material of the proper type and size.

4.4.2.7 Washing other material. With a dual- or multiple-media filter bed, each material shall be washed and scraped or skimmed as the purchaser requires to remove excess fine materials before the next material is installed.

4.4.3 *Top Surface Elevation.* The top surface of the filter material after initial washing (Sec. 4.5.1.1) shall have an elevation equal to the finished elevation plus the thickness of material to be removed by scraping.

4.4.4 *Contamination.* Any filter media that becomes contaminated after placement shall be removed and replaced with clean material of the proper type and size.

Sec. 4.5 Preparing Filter for Service

4.5.1 *Washing.*

4.5.1.1 Initial wash. After all filter materials have been placed, wash water shall be admitted slowly upward through the underdrain system until the entire bed is flooded. The bed shall be allowed to stand for as long a period as the purchaser requires to saturate the media before the initial wash. This period shall not be less than 12 h if the bed has been installed dry or allowed to stand dry. The wash rate shall be increased gradually during the initial wash to remove air from the bed.

4.5.1.2 Backwash rate. During each backwash, the water shall be applied at an initial rate of not more than 2 gpm/ft^2 of filter area. The backwash rate shall then be increased gradually over a period of 3 min to the maximum rate indicated in Table 2, and maintained at the maximum rate for not less than 5 min.

4.5.2 *Scraping.* After the initial wash, the filter shall be partially drained and a layer of fine material approximately $^3/_{16}$-in. thick shall be removed from the surface of the filter by scraping.

4.5.2.1 Repetitions. The scraping operation shall be repeated as many times as necessary to remove all fine material (these fines will be visible, giving a smooth appearance rather than the desired rough surface texture) and, in the case of anthracite, to remove all flat particles.

4.5.2.2 Number of washes. The filter shall be washed at least three times between scrapings. Each wash shall last at least 5 min and shall be at an appropriate rate as listed in Table 2.

Table 2 Maximum backwash rates

Water Temperature *°F*	Maximum Backwash Rate* *gpm/ft²*
50 or less	15
51–55	16
56–60	17
61–65	18.5
66–70	20
71–75	21
Above 75	22.5

*These maximum backwash rates are a guideline for 0.45 mm to 0.65 mm sand and 1.0 mm anthracite. The rates should be adjusted as necessary for other filter materials. The lowest maximum backwash rate should be that which fluidizes the bed and attains sufficient velocities to bring fines to the surface.

4.5.2.3 Additional material. If additional material is required to bring the top surface of the filter to the specified finished elevation, sufficient material shall be added before the final scraping operation. Adequate material shall be added to anticipate the final scraping.

4.5.2.4 In-place media sampling. If in-place samples of media are required by the purchaser, composite samples shall be prepared from a minimum of four filters after they have been backwashed and drained. Core samples shall be taken using a 2-in. diameter core sampler. It shall be inserted to the elevation just above the gravel interface, and then removed by excavating around it in order to extract a complete profile of material above that elevation. Composite samples from each filter shall consist of equal portions from a minimum of five cores distributed over each media surface.

1. Sample preparation. Upon receipt of the samples, the laboratory shall prepare them in the following manner:

   a. Place 0.25 L to 0.5 L of media sample in a 1-L or 1-gal bottle.

   b. Fill the bottle to within 1 in. of the top with clean water.

   c. Place cap on bottle and shake for 2 min using two or three forward and backward motions per second.

   d. Allow the media to settle, then decant the supernatant liquid into a clean container.

   e. Repeat steps b through d until supernatant is clean.

   f. If coal or granular activated carbon is used as the top layer, then separate that media from the sand by using the technique described in ASTM D4371.

2. Testing. Test samples in accordance with Sec. 5.3.

4.5.3 *Disinfecting*. After all work related to placement of media has been completed, and before the filter is placed in service, the entire filter shall be disinfected by chlorination in accordance with ANSI/AWWA C653, unless otherwise specified in the purchaser's specifications. The procedure for disinfection of granular activated carbon will be stipulated in a planned revision to ANSI/AWWA B604.

SECTION 5: VERIFICATION

Sec. 5.1 Approval Samples

When specified, a representative sample of each size of filter material shall be submitted for approval before shipment. The sample shall be submitted in clean, dust-tight containers plainly marked with the name and address of the supplier and the size or grade of the contents. After approval of the samples, shipments shall be of a quality equal to the sample. Approval samples shall meet the requirements of Sec. 5.2.

Sec. 5.2 Sampling

Sampling of filter materials shall be performed in accordance with ASTM D75 as modified and supplemented herein. The size of the composite samples shall be as indicated in Table 3.

5.2.1 *Bulk shipments*. Bulk shipments are not recommended (see foreword, Sec. II.F). Representative media samples in a bulk shipment are obtained most easily at either the production or loading point. When a truck or railcar is filled at the production site, sampling across the cross section of flow of the material being loaded is recommended. The composite sample shall be prepared in accordance with Sec. 5.2.4, with the weight of the sample as given in Table 3. A composite sample shall be taken as each railcar or truck is filled. It is not recommended that filter materials be sampled on receipt at the jobsite. However, if the purchaser specifies sampling on receipt, samples shall be taken from 10 locations in the railcar or truck. The railcar or truck shall be sampled near, but not in, each corner, at the center, and at five other random locations.

5.2.2 *Bag shipments*. When material is shipped to the jobsite in bags, representative samples shall be collected using a core sampler. The representative samples from each bag shall be combined to produce the required composite sample. The minimum size of the composite sample is provided in Table 3. The number of bags to be sampled is indicated in Table 4.

5.2.3 *Semibulk container shipments.* While semibulk containers are filled at the production site, sampling across the cross section of the material being loaded is recommended. The composite sample shall be prepared in accordance with Sec. 5.2.4, with the weight of the sample as indicated in Table 3. The number of semibulk containers to be sampled during filling shall be as indicated in Table 4. At

Table 3 Minimum size of composite sample

Maximum Size of Particle in Sample		Minimum Sample Size	
mm	*(in.)*	*kg*	*(lb)*
63.0	(2½)	45.0	(100)
37.5	(1½)	32.0	(70)
25.4	(1)	23.0	(50)
19.0	(¾)	14.0	(30)
12.5	(½)	9.0	(20)
9.5	(⅜) and smaller	4.5	(10)

Table 4 Sampling of bagged media*

Lot Size (number of bags shipped)	Minimum Sample Sizes (number of bags)
2–8	2
9–15	3
16–25	5
26–50	8
51–90	13
91–150	20
151–280	32
281–500	50
501–1,200	80
1,201–3,200	125
3,201–10,000	200
10,001–35,000	315
35,001–150,000	500

*Refer to Military Standard MIL-STD-105D (1963).

least one composite sample shall be generated for each size and type of material per railcar load or truckload.

5.2.4 *Composite sample.* The composite sample shall be reduced to representative samples for testing in accordance with ASTM C702. Samples shall be tested by the methods indicated in Sec. 5.3.

Sec. 5.3 Test Procedures—General

If filter materials testing is not witnessed at the shipping point by the purchaser, the material should be tested at the jobsite. The material shall be sampled in accordance with ASTM D75 and reduced to testing size in accordance with ASTM C702. A portion of the reduced sample should be retained for possible independent analysis.

5.3.1 *Acid solubility.* The acid-solubility test is performed by immersing a known weight of material in 1:1 hydrochloric acid (HCl) (made by combining equal volumes of 1.18 specific gravity HCl and H_2O) until the acid-soluble materials are dissolved, then determining the weight loss of the material. The minimum sample size and the minimum quantity of concentrated HCl diluted one-to-one with distilled water are indicated in Table 5.

5.3.1.1 Procedure. The procedure for testing acid-solubility shall include the following:

1. Wash sample in distilled water and dry at 110°C ± 5°C to constant weight.
2. Allow sample to cool in a desiccator. Weigh dried sample to the nearest 0.1 percent of the weight of the sample.
3. Place sample in beaker and add enough 1:1 HCl to immerse the sample completely, but not less than the quantity indicated in Table 5.
4. Allow to stand, with occasional stirring, at room temperature for 30 min after effervescence ceases.
5. Wash sample several times in distilled water and dry at 110°C ± 5°C to constant weight.

Table 5 Minimum sample and acid quantities for acid-solubility tests

Maximum Size of Particle in Sample *mm*	*(in.)*	Minimum Sample Weight *g*	Minimum Quantity 1:1 HCl *mL*
63.0	(2½)	4,000	7,000
37.5	(1½)	250	800
25.4	(1)	250	800
19.0	(¾)	250	800
12.5	(½)	250	800
9.5	(⅜) and smaller	100	320

6. Allow sample to cool in a desiccator and weigh to the nearest 0.1 percent of the weight of the sample.

7. Report the loss in weight as acid-soluble material.

5.3.1.2 Calculation.

To calculate acid-soluble material, the following equation shall be used:

$$\text{acid solubility (\%)} = \frac{\text{loss of weight}}{\text{original weight}} \times 100 \qquad \text{(Eq 1)}$$

Duplicate tests shall be made on each size of the material and the two results averaged. If the two results do not agree within 2 percent of the total sample weight, then two additional tests shall be made and the four determinations averaged.

5.3.2 *Gravel shape*. The following definitions and tests shall be used in identifying fractured, flat, or elongated pieces of gravel. Identification of fractured, flat, or elongated particles is to be done by visual separation.

5.3.2.1 Fractured face definition. A fractured face is defined as a surface surrounded by sharp edges, such as those produced by crushing, that occupy more than approximately 10 percent of the total surface area of the particle. This is intended to exclude a surface with small nicks and chips from classification as a fractured face.

5.3.2.2 Shape determination. The ratio of the longest axis to the shortest axis of the circumscribing rectangular prism for a piece of gravel shall be determined using a caliper or a proportional divider. Suspected elongated pieces can be checked by comparing the minimum thickness of the particle, as measured at its approximate midpoint, with the maximum length dimension.

5.3.3 *Specific gravity.* The specific gravity of filter silica gravel shall be determined in accordance with ASTM C127 and shall be reported as saturated-surface-dry specific gravity or the Noble Large Aggregate Test. The specific gravity of high-density gravel, high-density sand, silica sand, and filter anthracite shall be determined in accordance with ASTM C128 and shall be reported as apparent specific gravity. Anthracite may also be tested for float/sink in accordance with ASTM D4371.

5.3.3.1 Noble Large Aggregate Test Procedure.

1. Soak the sample in water at room temperature (approx. 73°F) for 24 h.
2. Set the water reservoir on a level surface with the cylinder valve closed.
3. Fill the reservoir with room temperature water to a depth where the valve opening is totally submerged.
4. After 5 min, open the valve and allow the excess water to drain. Close the valve after the last drop has drained.

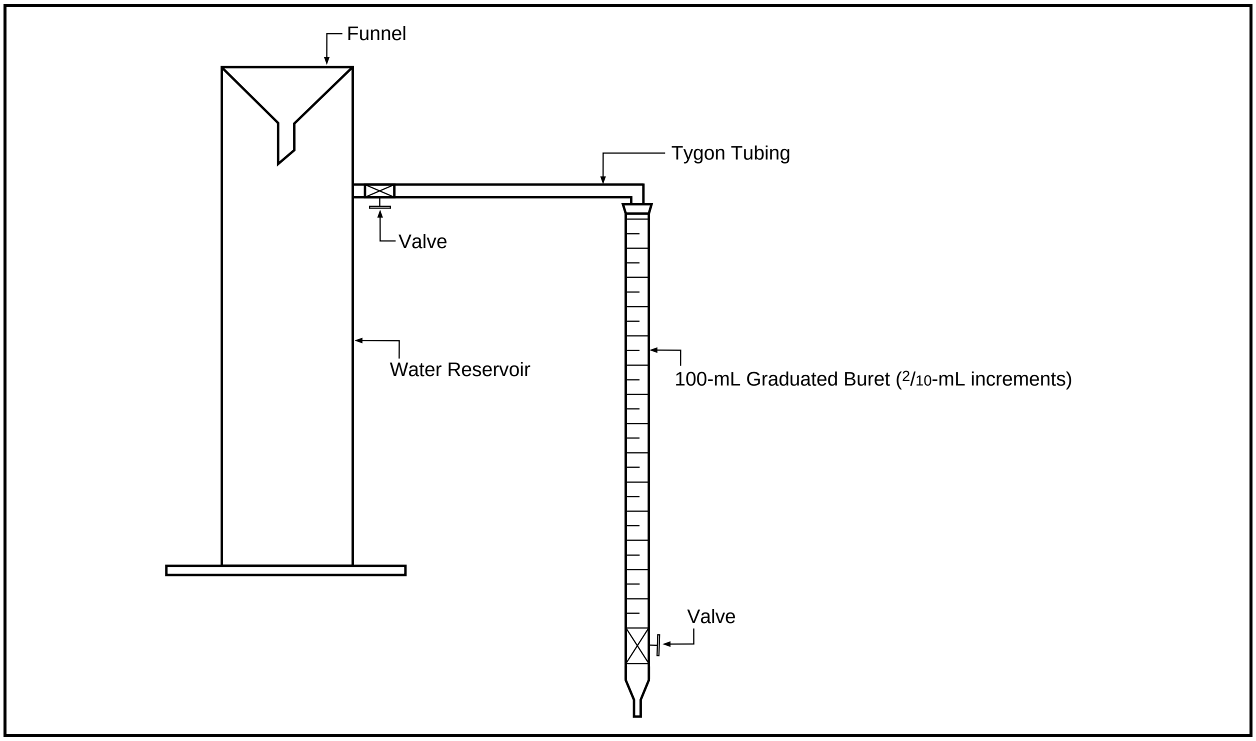

Figure 1 Specific gravity test apparatus

5. Remove the presoaked sample from the water and pat the sample dry with a dry cloth or paper towels to a saturated surface dry (SSD) condition.

6. Immediately weigh the sample to the nearest 0.1 g.

7. With a funnel, or by hand, carefully drop the preweighed sample into the water reservoir as indicated in Figure 1. Leave the sample submerged for 15 min while tapping on the sides of the reservoir and stirring to free the entrapped air.

8. Place the graduated buret (with valve closed) under the transparent vinyl plastic (tygon) tubing. Open the cylinder valve to allow the displaced water to drain into the graduated buret to its last drop. Allow the buret tip to fill before taking a final volume reading.

9. Read the water volume in millilitres.

10. Perform calculation.

Bulk specific gravity (saturated surface dry) = Item 6/Item 9

5.3.4 *Sieve analyses.* Sieve analyses for filter materials shall be performed in accordance with ASTM C136, as modified and supplemented herein.

5.3.4.1 Principle. Particle sizes shall be determined by screening through standard sieves conforming to ASTM E11. Particle size shall be defined in terms of the smallest sieve opening through which the particle passes.

5.3.4.2 Sample size. The minimum sample size for sieve analyses shall be as indicated in Table 6.

5.3.4.3 Procedure. The sieving procedure shall be in accordance with ASTM C136. Care shall be taken to avoid breaking anthracite particles when sieving. Generally, sieves require machine shaking times of 10 min ± 0.5 min for sand or gravel and 5 min ± 0.5 min for anthracite. All standard sieves used for testing filter materials shall conform to the tolerances required in ASTM E11. If questions of

Table 6 Minimum sample size for sieve analyses

Maximum Size of Particle in Sample		Minimum Sample Weight	
mm	*(in.)*	*kg*	*(lb)*
63.0	(2½)	23.0	(50)
37.5	(1½)	16.0	(35)
25.4	(1)	11.0	(25)
19.0	(¾)	6.8	(15)
12.5	(½)	4.5	(10)
9.5	(⅜)	2.3	(5)
No. 4 (4.75)		500.0 g	
No. 8 (2.36)		100.0 g	

compliance to specifications arise when nominal standard sieve openings are used, standard reference materials (glass spheres) certified by the National Bureau of Standards should be used in accordance with their calibration procedure to accurately determine the effective opening size of each sieve. If standard reference material for calibration is not used, then the data shall be replotted using both the maximum and minimum permissible variation of average opening from the standard sieve designation as shown in Table 1, column 4 of ASTM E11. (Sections of ASTM E11, column 4, are reprinted in Appendix B, Table B.1.) The materials shall be in compliance if either of the plots agrees with the specifications.

To avoid excessive interpolation when determining the effective size (the size opening that 10 percent of the particles can pass) and the D60 (the size opening that 60 percent of the particles can pass), the sieves used on a particular sieve analysis shall have openings such that the ratio between adjacent sizes is the fourth root of 2, or 1.1892. The sieves shall be chosen so that the nominal opening of only one sieve is smaller than the smallest allowable effective size so that the greatest range of particle size distribution can be measured in one standard nest of six sieves. If the media specification limits the quantity of fines, an additional sieve shall be added for a total of seven sieves, so that there are two sieve measurements taken below the effective size.

5.3.4.4 Calculation. The cumulative percent passing each sieve shall be calculated and plotted on log-probability paper or semilog paper, with the sieve opening on the log scale and the cumulative percent passing on the probability scale or linear scale. A smooth curve shall be drawn through the points plotted.

5.3.4.5 Uniformity coefficient. Read from the curve the sieve size corresponding to the 10 percent size, which is the effective size in millimetres. Read the 60 percent size and divide this by the 10 percent size. This ratio is the uniformity coefficient.

5.3.4.6 Mohs' scale of hardness. No standard test method has been found; however, all commercial laboratories follow the same procedure.

5.3.5 *Rejection.* If the filter materials do not meet the applicable requirements of this standard, they shall be removed from the site. An independent laboratory deemed acceptable by the purchaser may be employed by the constructor, manufacturer, or supplier to sample and test the disputed material before its removal. Once media has been placed in filters, every filter must meet the size specifications.

5.3.5.1 Additional field tests. At the option of the purchaser, constructor, manufacturer, or supplier, two additional tests shall be conducted using two additional representative samples and a mutually acceptable independent laboratory. Unless otherwise agreed on between the purchaser and constructor, the results of all tests shall be averaged arithmetically. If the independent laboratory reports that the material complies with the applicable requirements of this standard, the purchaser shall accept the material. If the material does not meet the requirements of this standard, the constructor shall promptly remove the material from the jobsite.

5.3.5.2 Alternative to removal. As an alternative to removing the rejected material, the constructor may, with the purchaser's approval and control, reprocess the material at the jobsite to meet the applicable requirements.

SECTION 6: DELIVERY

Sec. 6.1 Marking

6.1.1 *Required.* Each package and container shall have marked legibly on it the name of the material, the gradation, the filling date, the net weight of the contents, the name of the manufacturer, the lot number, and the brand name, if any, and shall bear such other markings as are required by the US Department of Transportation and other applicable regulations and laws. When shipped in bulk, this information shall accompany the bill of lading.

6.1.2 *Optional.* Packages may also bear the statement, "This material meets the requirements of AWWA B100, Standard for Filtering Materials," provided that the requirements of this standard are met and the material is not of a different quality in separate agreement between the supplier or constructor and purchaser.

Sec. 6.2 Packaging and Shipping

Shipment shall be made in bags or semibulk containers or in clean railcars or trucks with tight closures to avoid loss or contamination of material in transit.

6.2.1 *Bags.* When specified, shipment shall be made in suitable new and unused heavy-duty cloth, paper, woven polypropylene, or polyethylene bags that contain ultraviolet (UV) light inhibitors and shall contain not more than 1 ft^3 of material. Each bag shall be marked in an appropriate manner so that its contents are identified.

6.2.2 *Semibulk containers.* When specified, shipment shall be made in suitable new, unused, heavy-duty, woven, polypropylene semibulk containers, treated with UV light inhibitors, and having a safety factor of at least 5:1. Each container shall hold one or more tons of material. To aid in handling, semibulk containers should have attached straps or sleeves strong enough to support their entire weight when full. Each semibulk container shall be marked so that its contents are identified.

6.2.3 *Bulk.*

1. Bulk shipment is not recommended for reasons described in the foreword.
2. When truck shipment is specified, and where a liner is not used, shipment shall be made in clean truck containers. Truck containers shall be cleaned before loading by washing with water that is 180°F or hotter. Provisions for tight covering shall be made to avoid loss and to prevent contamination. The trucks shall be exclusively dedicated to hauling potable water filtering materials.
3. When railroad hopper car shipment is specified, shipment shall be made in clean cars lined with an impermeable plastic liner and tight closures to avoid loss

and contamination. If open-top cars are used, they shall be tightly covered. The purchaser is cautioned that potential contamination of the product is possible because of the absence of hopper cars dedicated solely to filter materials.

6.2.4 *Shipping notice.* When a shipment of material is being loaded, the constructor shall notify the purchaser of the railcar number and the date of shipment. The shipping notice shall contain a certification of the particle size distribution of the material in the shipment.

Sec. 6.3 Affidavit of Compliance

When specified by the purchaser, the manufacturer, supplier, or constructor shall provide an affidavit of compliance stating that the filter materials furnished comply with the applicable provisions of this standard.

APPENDIX A
Bibliography

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

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APPENDIX B
Calibration of Sieves

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

Section B.1 Precision of Sieves

Although sieves are made from carefully selected brass wire cloth with meshes that are as square and even-sized as possible, it is rare that they will have exactly the same size openings, even when made from the same piece of material. For precise work, all sieves should be calibrated according to the procedures in ASTM* E11, Specification for Wire-Cloth Sieves for Testing Purposes. (For nominal dimensions for wire cloth of standard test sieves, see Table B.1).

Section B.2 Glass Spheres

For routine checking of sieves and for determining the effective sieve openings, a method that employs glass spheres is recommended. The glass spheres should not be used to determine conformity to specifications. Glass spheres for use in sieve calibration may be obtained from the National Institute of Standards.† Four of these standard reference materials are now available, including SRM 1019a for calibrating sieves No. 8 to No. 35; SRM 1018a for calibrating sieves No. 20 to No. 70; SRM 1017a for calibrating sieves No. 50 to No. 170; and SRM 1004 for calibrating sieves No. 140 to No. 400. Detailed instructions on the use of the glass spheres for calibrating sieves are furnished with each sample.

*American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

†National Institute of Standards and Technology, Supply Division, Bldg. 301, Gaithersburg, MD 20899.

Table B.1 Nominal dimensions, permissible variations for wire cloth of standard test sieves (USA Standard Series)*

Sieve Designation Standard†	Sieve Designation Alternative	Nominal Sieve Opening *in.*‡	Permissible Variation of Average Opening From the Standard Sieve Designation	Maximum Opening Size for Not More Than 5 Percent of Openings	Maximum Individual Opening	Nominal Wire Diameter *mm*§
125 mm	5 in.	5	±3.7 mm	130.0 mm	130.9 mm	8.0
106 mm	4.24 in.	4.24	±3.2 mm	110.2 mm	111.1 mm	6.40
100 mm**	4 in.**	4	±3.0 mm	104.0 mm	104.8 mm	6.30
90 mm	3½ in.	3.5	±2.7 mm	93.6 mm	94.4 mm	6.08
75 mm	3 in.	3	±2.2 mm	78.1 mm	78.7 mm	5.80
63 mm	2½ in.	2.5	±1.9 mm	65.6 mm	66.2 mm	5.50
53 mm	2.12 in.	2.12	±1.6 mm	55.2 mm	55.7 mm	5.15
50 mm**	2 in.	2	±1.5 mm	52.1 mm	52.6 mm	5.05
45 mm	1¾ in.	1.75	±1.4 mm	46.9 mm	47.4 mm	4.85
37.5 mm	1½ in.	1.5	±1.1 mm	39.1 mm	39.5 mm	4.59
31.5 mm	1¼ in.	1.25	±1.0 mm	32.9 mm	33.2 mm	4.23
26.5 mm	1.06 in.	1.06	±0.8 mm	27.7 mm	28.0 mm	3.90
25.0 mm**	1 in.**	1	±0.8 mm	26.1 mm	26.4 mm	3.80
22.4 mm	⅞ in.	0.875	±0.7 mm	23.4 mm	23.7 mm	3.50
19.0 mm	¾ in.	0.750	±0.6 mm	19.9 mm	20.1 mm	3.30
16.0 mm	⅝ in.	0.625	±0.5 mm	16.7 mm	17.0 mm	3.00
13.2 mm	0.530 in.	0.530	±0.41 mm	13.83 mm	14.05 mm	2.75
12.5 mm**	½ in.**	0.500	±0.39 mm	13.10 mm	13.31 mm	2.67
11.2 mm	7⁄16 in.	0.438	±0.35 mm	11.75 mm	11.94 mm	2.45
9.5 mm	⅜ in.	0.375	±0.30 mm	9.97 mm	10.16 mm	2.27
8.0 mm	5⁄16 in.	0.312	±0.25 mm	8.41 mm	8.58 mm	2.07
6.7 mm	0.265 in.	0.265	±0.21 mm	7.05 mm	7.20 mm	1.87
6.3 mm**	¼ in.**	0.250	±0.20 mm	6.64 mm	6.78 mm	1.82
5.6 mm	No. 3½††	0.223	±0.18 mm	5.90 mm	6.04 mm	1.68
4.75 mm	No. 4	0.187	±0.15 mm	5.02 mm	5.14 mm	1.54

*From ASTM E11 (Reprinted, with permission)

†These standard designations correspond to the value for test sieve apertures recommended by the International Organization for Standardization (ISO), Geneva, Switzerland.

‡Only approximately equivalent to the metric values in column 1.

§The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following:

Sieves coarser than 600 μm	5 percent
Sieves 600–125 μm	7.5 percent
Sieves finer than 125 μm	10 percent

**These sieves are not in the standard series, but they have been included because they are in common usage.

††These numbers (3½–400) are the approximate number of openings per linear inch, but it is preferred that the sieve be identified by the standard designation in millimetres or micrometres.

‡‡1,000 μm = 1 mm.

Table continued next page.

Table B.1 Nominal dimensions, permissible variations for wire cloth of standard test sieves (USA Standard Series)* (continued)

Sieve Designation Standard†	Sieve Designation Alternative	Nominal Sieve Opening *in.*‡	Permissible Variation of Average Opening From the Standard Sieve Designation	Maximum Opening Size for Not More Than 5 Percent of Openings	Maximum Individual Opening	Nominal Wire Diameter *mm*§
4.00 mm	No. 5	0.157	±0.13 mm	4.23 mm	4.35 mm	1.37
3.35 mm	No. 6	0.132	±0.11 mm	3.55 mm	3.66 mm	1.23
2.80 mm	No. 7	0.111	±0.095 mm	2.975 mm	3.070 mm	1.10
2.36 mm	No. 8	0.0937	±0.080 mm	2.515 mm	2.600 mm	1.00
2.00 mm	No. 10	0.0787	±0.070 mm	2.135 mm	2.215 mm	0.900
1.70 mm	No. 12	0.0661	±0.060 mm	1.820 mm	1.890 mm	0.810
1.40 mm	No. 14	0.0555	±0.050 mm	1.505 mm	1.565 mm	0.725
1.18 mm	No. 16	0.0469	±0.045 mm	1.270 mm	1.330 mm	0.650
1.00 mm	No. 18	0.0394	±0.040 mm	1.080 mm	1.135 mm	0.580
850 µm‡‡	No. 20	0.0331	±35 µm	925 µm	970 µm	0.510
710 µm	No. 25	0.0273	±30 µm	774 µm	815 µm	0.450
600 µm	No. 30	0.0234	±25 µm	660 µm	695 µm	0.390
500 µm	No. 35	0.0197	±20 µm	550 µm	585 µm	0.340
425 µm	No. 40	0.0165	±19 µm	471 µm	502 µm	0.290
355 µm	No. 45	0.0139	±16 µm	396 µm	425 µm	0.247

*From ASTM E11 (Reprinted, with permission).

†These standard designations correspond to the value for test sieve apertures recommended by the International Organization for Standardization (ISO), Geneva, Switzerland.

‡Only approximately equivalent to the metric values in column 1.

§The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following:

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††These numbers (3½–400) are the approximate number of openings per linear inch, but it is preferred that the sieve be identified by the standard designation in millimetres or micrometres.

‡‡1,000 µm = 1 mm.

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