

American Water Works Association

ANSI/AWWA B604-96

(Revision of ANSI/AWWA B604-90)



AWWA STANDARD
FOR
GRANULAR ACTIVATED CARBON



Effective date: Mar. 1, 1997.

First edition approved by AWWA Board of Directors Jan. 28, 1974.

This edition approved June 23, 1996.

Approved by American National Standards Institute Nov. 27, 1996.

AMERICAN WATER WORKS ASSOCIATION

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Foreword

This foreword is for information only and is not a part of AWWA B604.

I. Introduction

I.A. *Background.* Activated carbon is a form of carbon that is produced by a carefully controlled oxidation process to develop a porous carbon structure with a surface area greater than 500 m²/g. This surface area gives the activated carbon the capacity to adsorb dissolved organic materials, many of which are taste- and odor-causing substances in water.

The major raw materials used in the manufacture of granular activated carbons (GAC) include, but are not limited to, peat, bituminous coal, coconut shells, wood, and lignite. During activation, the raw materials are either reacted at high temperatures in the presence of steam or at more moderate temperatures in the presence of certain activation chemicals. These activation processes carbonize the raw materials and develop the extensive internal pore structure required to obtain appreciable adsorption. Subsequent processing may include crushing, screening, grading, and packaging.

Water treatment with granular activated carbon is accomplished by percolating the water to be treated through fixed-adsorption beds of granular activated carbon. The granular activated carbon may be crushed and screened to any particle size, but typical sizes used for water treatment range from No. 8 to No. 50 US standard sieve sizes.

I.A.1 *Source of supply.* Activated carbon to be used in water treatment should be obtained from manufacturers regularly engaged in the production of activated carbon found satisfactory for service in the water treatment field.

I.B. *History.* The first edition of ANSI/AWWA B604, Standard for Granular Activated Carbon, was approved by the AWWA Board of Directors on Jan. 28, 1974. The first revision of ANSI/AWWA B604 was approved on June 17, 1990. This is the second revision. This edition was approved by the AWWA Board of Directors on June 23, 1996.

ANSI/AWWA B604 provides information on preparing specifications for granular activated carbon used as an adsorption medium and filtration/adsorption medium for the treatment of municipal and industrial water supplies. Powdered activated carbon is covered in ANSI/AWWA B600, and other filtering materials are covered in ANSI/AWWA B100.

This standard does not cover the design of carbon-handling facilities or adsorption processes. Design information may be found in *Journal AWWA* and in other publications, some of which are listed in the bibliography (appendix A) to this standard.

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.
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 60. 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 60 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 B604-96 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. *Handling and Storage.* Wet activated carbon will readily adsorb oxygen from the air, creating an acute oxygen depletion hazard in confined areas. Appropriate safety measures for oxygen-deficient atmospheres should be strictly adhered to when entering enclosed or partially enclosed areas containing activated carbon.

In storing activated carbon, precautions must be taken to avoid direct contact with strong oxidizing agents, such as chlorine, hypochlorites, potassium permanganate, ozone, and peroxide.

*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.

[§]Both publications available from National Academy of Sciences, 2102 Constitution Ave. N.W., Washington, DC 20418.

Mixing carbon with hydrocarbons (such as oils, gasoline, diesel fuel, grease, paint thinners, and so forth) may cause spontaneous combustion. Therefore, activated carbon must be kept separated from hydrocarbon storage or spills.

Activated carbon dusts are classified as “nuisance particulates” and the applicable Threshold Limit Values (TLVs) should be followed.*

II.B. *Filter Media.* Filter media are those portions of the filter bed that remove particulate matter from the water during the filtration process. This standard covers granular activated carbon which serves as both an adsorbent and filter medium. Properties of other filter media such as sand, anthracite, and filter media support such as gravel are contained in ANSI/AWWA B100.

II.C. *GAC Size Distribution.* The selection of the type, size, and bed depth of GAC in any particular application is site specific and depends on the raw water quality, pretreatment provided, and water quality objectives. These are site-specific design criteria and must be determined by the design engineer.

In general, for a given pretreatment of raw water and a given filtration rate, coarse media will permit longer filtration runs, but the rate of adsorption is slower. The organic removal and filtration efficiency will normally decrease as the particle size is increased. However, the head loss will also increase with decreasing particle size, and, as a result, the filter runs may be shorter. The uniformity coefficient (UC) of GAC used as a filter medium may be less than the UC of GAC used as an adsorbent. Experience indicates that a more uniform media results in greater filtration efficiency.

Dual- or multi-media GAC filters have been used in lieu of a single medium in standard filter-adsorbers for water treatment. The dual or multi-media are selected to provide a coarse layer of GAC in the upper filter with the smaller and more dense sand in the lower layers. This coarse-to-fine grading combines longer filter runs with the superior filtration characteristics of finer media. Obviously, the larger media must be lighter than the smaller media to provide the desired gradation, and the relative sizes of the various media should be selected on the basis of the desired backwash properties. Therefore, the relative size depends on the density and shape of the media, as well as particle size. It should also be noted that intermixing sand with GAC may introduce reactivation problems.

Since granular activated carbon is normally used as a filter medium due to the adsorption characteristics, the adsorption properties of the material must be considered. Efficient adsorption requires that the adsorption wave front of the GAC be maintained during the backwash/filtration cycle. Excessive intermixing of the GAC will reduce the adsorption capacity of the filter bed material and increase the cost of operation. Maintaining a stratified bed is more difficult with GAC than with other media such as sand or anthracite. As the activated carbon granules in the upper portion of the bed adsorb organic materials, the density increases and the particles settle to a lower portion of the bed. To assist in the maintenance of bed stratification, the adsorption wave front, and efficient adsorption, GAC is typically produced to be as nonuniform as possible. That is, the GAC is produced as non-uniform as possible without reaching the transport velocity of the smallest particles prior to achieving expansion of the largest fraction. This normally occurs at a uniformity coefficient of approximately 2.1. Where filtration is the primary function of the GAC,

*American Conference of Governmental Industrial Hygienists, 6500 Glenway Ave., Bldg. D-7, Cincinnati, OH 45211-4438.

more uniform carbons may be warranted. The design engineer must balance the adsorption performance with the filtration requirements.

In specifying the size of granular activated carbon, it is normal to express the effective size of the particle and maximum allowable uniformity coefficient, or the average particle size and maximum uniformity coefficient. An oversize and undersize allowance may also be specified on the mesh sizes that incorporate the desired carbon gradation. For example, when specifying an 8×30 mesh size, the maximum amount that is retained on the 8 mesh (oversize) and the maximum percent that passes the 30-mesh screen (undersize) may also be specified. Commonly manufactured size ranges for granular activated carbon are expressed in US standard sieve sizes that include, but are not limited to, 8×16 , 8×20 , 8×30 , 10×30 , 12×40 , 14×40 , 20×40 , and 20×50 , with effective size ranges from 0.35 mm to 2.0 mm. Extruded carbons are also produced in various size ranges. The typical properties of the more standard GAC products are shown in Table F.1.

II.D. *Adsorptive Capacity.* The optimum method for determining the effectiveness of a granular activated carbon is by using water from the particular plant in question for the test. These methods may include testing for removal of a specific challenge compound. Various surrogate tests have been developed that give an indication of a granular activated carbon's performance under specific conditions. These

Table F.1 Typical characteristics for a range of GAC products *

Standard US Mesh Size	Uniformity Coefficient	Effective Size (mm)	Apparent Density lb/ft ³
Bituminous Coal-Based GAC			
12 × 40	≤1.9	0.55–0.75	27–41
10 × 20	≤1.6	0.8–1.1	28–39
8 × 30	≤2.1	0.7–1.0	28–41
8 × 20	≤1.5	1.0–1.2	29–39
8 × 16	≤1.5	1.2–1.5	29–39
6 × 14	≤1.5	1.7–1.9	31–39
Lignite Coal-Based Carbons			
20 × 50	≤1.6	0.3–0.5	22–26
20 × 40	≤1.5	0.45–0.65	22–26
12 × 40	≤1.8	0.55–0.8	22–26
10 × 30	≤1.6	0.7–0.9	22–26
12 × 20	≤1.7	0.7–1.0	22–26
8 × 30	≤1.8	0.7–1.0	22–26
8 × 16	≤1.5	1.2–1.5	22–26
Wood-Based Granular Activated Carbons			
14 × 35	≤1.5	0.6–0.8	16–19
10 × 25	≤1.5	1.0–1.3	15–18
4 × 14	≤1.5	1.6–2.0	14–17

*The characteristics shown above represent a range of GAC products and not a specific grade and mesh size. Manufacturer's product data bulletins should be consulted for information on specific grades and particle sizes.

tests use a very high concentration of adsorbate to reduce the amount of time required to run the test. Sampling tubes may be added to the GAC vessel to aid in determining the adsorptive wavefront. Various producers of activated carbon suggest different adsorbates to give an index of a carbon's performance. Examples are phenol, tannin, iodine, and molasses. Phenol adsorption is an index of a carbon's ability to remove some types of chemical taste and odor; tannin is representative of organic compounds added to water by decayed vegetation; and iodine adsorption is an index of the total surface area of a carbon. Iodine and molasses adsorption are often used to show the degree of carbon activation. An iodine adsorption test is included in this standard. Information on tannin and phenol adsorptive capacity tests may be found in appendix B to this standard for those purchasers who want to include these requirements in their specifications. An American Water Works Association Research Foundation (AWWARF) protocol has also been developed for the evaluation of granular activated carbons. (See appendix A.)

II.E. Abrasion Resistance. Granular activated carbons used for municipal water treatment are exposed to a variety of external forces during shipping, loading into adsorption beds, backwashing, and reactivation. These forces can cause activated carbon granule crushing on impact, granule-to-granule abrasion, and the generation of undesirable fines. Because of the difficulty in devising a test that simulates the various handling conditions that may be encountered, the industry has not yet agreed on any one standard test for predicting activated carbon durability.

Two tests, the stirring abrasion test and the Ro-Tap abrasion test, have been included in this standard for measuring granular activated carbon durability. It is recognized that differences in bulk density and other physical properties of the various manufactured activated carbons, which might not be related to durability, influence the results obtained in using these tests. For this reason, it is current practice to use the stirring abrasion test for lignite-based granular activated carbons and the Ro-Tap abrasion test for bituminous-based granular activated carbons.

II.F. Reactivation. The characteristics of granular activated carbon have an impact on the physical and adsorptive losses during reactivation and must, therefore, be considered. Resistance to abrasion and the operating conditions required to restore the adsorptive capacity are significant factors in carbon losses and cost. A separate standard is being developed for reactivated GAC.

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 B604, Standard for Granular Activated Carbon, of latest revision.
2. Quantity of granular activated carbon to be purchased. Activated carbon intended for immediate placement in an adsorption bed is typically purchased by volume, and is backwashed, drained, and in place. Makeup activated carbon or activated carbon intended for subsequent placement is purchased on a volume or weight basis.
3. Whether an affidavit of compliance is required (Sec. 6.3).
4. Whether this is a supply contract or a supply and installation contract (Sec. 7).

5. Whether the purchaser requires additional adsorptive capacity tests (Sec. 4.2.2).

6. When requested, a representative sample of the granular activated carbon shall be submitted to the purchaser for acceptance before shipment. The sample must be submitted in clean, vaporproof containers, clearly marked with the address of the supplier, and identified with the lot number of the contents. A duplicate sample shall be tested by the supplier and a certified test report shall be submitted to the purchaser with the purchaser's sample, showing compliance with the requirements of the purchaser's specifications, along with a statement certifying that the material for shipment is equal in quality to the sample submitted.

7. The purchaser may elect to accept the granular activated carbon on the basis of (1) the supplier's certified test report and an accompanying affidavit of compliance indicating the product proposed for use complies with this standard and with the purchaser's specifications with no exceptions; (2) the supplier's certified test report completed by a qualified third-party testing laboratory approved by the purchaser and an accompanying affidavit of compliance; (3) the purchaser's own testing of the reference sample submitted by the supplier and the required affidavit of compliance; or (4) the purchaser's own testing of the representative sample, collected according to Sec. 5.1 after receipt of shipment, showing compliance with this standard and the purchaser's specifications. (See note in Sec. 4.1.1.)

8. Particle-size range, effective size, and uniformity coefficient, if other than that specified (Sec. 4.1).

9. Special adsorptive capacity tests (Sec. 4.2.1 and Sec. 4.2.2).

10. Provisions for reaching agreement on sampling technique (Sec. 5.1.1).

11. Method of packaging and shipping (Sec. 6.2).

12. If shipment is to be in bulk: type of railcar or hopper truck (Sec. 6.2.4); and whether bulk shipments are to be accompanied by weight certificates of certified weighers (Sec. 6.2.5).

13. The purchaser may authorize shipment on the basis of the supplier's certification of quality, or may test the reference sample submitted by the supplier to confirm compliance before shipment is authorized.

14. The purchaser may elect to collect a representative sample of the material after delivery. The procedure used shall be in accordance with Sec. 5.1. One of the three sample portions taken may be tested to determine compliance with the purchaser's specifications.

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. Parameters required to specify GAC as a filter/adsorber, as well as an adsorbent, have been included.

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, CO 80235.