American Water Works Association

AWWA B453a-07
Addendum to
ANSI/AWWA B453-06
Standard
for

Polyacrylamide

(Approved by the AWWA Board of Directors on June 24, 2007.)

Sec. III.A.2, added the following:

15. Whether alternative security measures have been adopted to replace or augment the security measures set out in Sec. 6.2.1 and 6.2.2.

16. Whether the purchaser will reject product from containers or packaging with missing or damaged seals. The purchaser may reject product from bulk containers or packages with missing or damaged seals unless the purchaser's tests of representative samples, conducted in accordance with Sec. 5.2, 5.3, and 5.4, demonstrate that the product meets specifications. Failure to meet specifications or the absence of, or irregularities in, seals may be sufficient cause to reject the shipment.

Section 3, added the following:

8. *Tamper-evident packaging:* Packaging having one or more indicators or barriers to entry which, if breached or missing, can reasonably be expected to provide visible evidence to the purchaser that tampering has occurred. The tamper-evident features of the packaging shall be designed to and shall remain intact when handled

in a reasonable manner during manufacture, storage, shipment, and delivery to the purchaser. Properly constructed, labeled, and closed multiwall paper bags and super-sacks constitute two forms of tamper-evident packaging.

Section 6, added the following:

6.2.1 *Security requirements for nonbulk shipments*. Packaged product shall be stored, shipped, and delivered in tamper-evident packaging as defined in Section 3, or an alternative method or methods may be agreed upon by the manufacturer and purchaser that would provide a reasonable assurance of protection against tampering.

6.2.2 *Security requirements for bulk shipments.* Bulk quantities of product shall be secured by employing one of the following security measures (or a combination of measures):

6.2.2.1 Seals. Bulk quantities of product may be sealed with a uniquely numbered tamper-evident seal(s). The seal numbers shall be recorded and disclosed on shipping documents, such as the bill of lading. Seals shall be inspected on receipt of product by the purchaser and evidence of tampering or removal should be reported to the carrier and supplier.

6.2.2.2 Chain of custody. A continuous chain of custody may be maintained between the manufacturer and the purchaser during storage and shipment, if so specified by the purchaser.

6.2.2.3 Alternative method. An alternative method or methods agreed upon by the manufacturer and purchaser may be implemented that would provide reasonable assurance of protection against tampering.

ANSI/AWWA B453-06
(Revision of ANSI/AWWA B453-01)

American Water Works Association

The Authoritative Resource on Safe Water®

AWWA Standard

Polyacrylamide

ANSI American National Standards Institute

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AWWA Standard

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AWWA unites the entire water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.

Committee Personnel

The AWWA Standards Committee on Polyelectrolytes, which reviewed and approved this standard, had the following personnel at the time of approval:

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*Liaison, nonvoting

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

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA B453.

I. Introduction.

I.A. *Background.* Chemical clarification methods have been used to improve the quality of drinking water supplies since the late 1880s. In 1967, the first completely synthetic organic polyelectrolyte was accepted by the US Public Health Service for use in treatment of potable water. The responsibility for accepting additives for drinking water treatment was subsequently assumed by the US Environmental Protection Agency (USEPA) and administered by their Office of Drinking Water as an advisory program. USEPA's acceptance was by the specific name of the suppliers' product and not by generic type. Polyacrylamide (CAS* No. 9003-05-8) is one of several types of synthetic organic polyelectrolytes that were accepted for use in potable water treatment under this program, which was discontinued in 1990.

Polyacrylamides (PAMs) belong to a family of synthetic organic polyelectrolytes (also called polymers or flocculants) used in water treatment to improve the performance of some unit operations in the treatment process, most often by increasing the extent or rate of liquid–solids separation. PAMs may have an anionic, nonionic, or cationic charge and will always have a high relative molecular weight. Because of this high molecular weight, they are manufactured for the potable water supply service in three distinctly different product forms: powders, emulsions, and solutions. The solution form is the least frequently used because of its high viscosity and lower polymer content. An aqueous dispersion form may be available in the future.

The important concepts to remember regarding PAMs include the following:

1. PAMs differ from polyDADMAC polymers (ANSI/AWWA Standard B451, Poly [Diallydimethylammonium Chloride]) and epichlorohydrin-DMA polymers (ANSI/AWWA Standard B452, EPI-DMA Polyamines) in their use, handling, storage, and solution preparation.

2. PAMs are not one polymer, but a family of polymers that differ in product form, charge type, charge density, molecular weight, and other properties.

*Chemical Abstracts Service, 2540 Olentangy River Road, P.O. Box 3012, Columbus, OH 43210.

3. The nomenclature used to describe the four forms in which PAMs are supplied is

a. Powders (also called flake, dry, granular, or bead).

b. Emulsions (also called liquids, dispersions, or inverse emulsions).

c. Solutions (also called liquids, aqueous solutions, or viscous solutions).

d. Aqueous dispersions (also called oil-free emulsion, water dispersion, brine dispersion).

4. The physical properties of a PAM cannot usually be used to judge product performance. Only through laboratory testing, pilot-plant studies, or full-plant trials can product efficacy be discerned.

5. PAMs may or may not contain inactive ingredients, such as hydrocarbon solvents, surfactants, and salts, depending on the product form, manufacturing method, and formulation. The typical primary components of each form can be described generically as follows:

a. Powders (PAM, moisture [water]; may contain inert inorganic salts or inert organic compounds).

b. Emulsions (PAM, hydrocarbon oil, water, surfactants). The amount of hydrocarbon oil is typically, but not limited to, 20 percent to 50 percent by weight of the emulsion.

c. Solution (usually a dilute, viscous, aqueous solution of powder or emulsion form PAM. Refer to the aforementioned primary components).

d. Aqueous dispersions (PAM, water, salts) in which the PAM is suspended in aqueous solution of inorganic salts. Aqueous dispersion PAMs are currently used for wastewater treatment and may be introduced in the future for potable water supply treatment subject to appropriate approvals. These products contain no hydrocarbon oil or surfactants.

The user should consult the material safety data sheet (MSDS) for product composition information regarding any specific PAM product.

6. The storage, dissolution, and feeding of PAMs may require specific procedures, considerations, and equipment that are unique for each product form (powders, emulsions, and solutions).

I.B. *History.* Authorization for development of this standard was given by the AWWA Standards Council. The standard was developed by the AWWA Standards Committee on Polyelectrolytes and the first edition was approved by the AWWA Board of Directors on Feb. 4, 1996. Subsequent action was approved by the Board of

Directors on June 17, 2001. This third edition was approved by the AWWA Board of Directors on Feb. 12, 2006.

I.C. *Acceptance.*[*] In May 1985, 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 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 two standards developed under the direction of NSF, NSF[‡]/ANSI[§] 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 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.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 60 does not stipulate a Single Product Allowable Concentration (SPAC) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The SPACs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

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[*] See Sec. 4.6.2, which gives the USEPA Treatment Technique requirements for residual acrylamide monomer in polyacrylamide polymers.

[†] Persons outside the United States should contact the appropriate authority having jurisdiction.

[‡] NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48113.

[§] American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

ANSI/AWWA B453 addresses additives requirements in Sec. 4.6 of the standard. The transfer of contaminants from chemicals to processed water or the residual solids is becoming a problem of greater concern. The language in Sec. 4.6.4 is a recommendation only for direct additives used in the treatment of potable water to be certified by an accredited certification organization in accordance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects. However, users of the standard may opt to make this certification a requirement for the product. 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. *Safety.* PAMs are not considered to be as toxic as some household products nor are they considered to be primary skin or eye irritants as defined by the Consumer Product Safety Commission (US Federal Hazardous Substances Act). Good housekeeping procedures and personal cleanliness are recommended when handling polyacrylamides. The products may contain trace amounts of acrylamide monomer, which has been shown to be toxic. The MCL of 0.05 percent is lower than that which would require labeling under the Occupational Safety & Health Administration (OSHA) Hazard Communication Standard.

Safety glasses should be worn when handling emulsion or solution forms of PAM and, although not required, when handling the powder form. Appropriate first-aid practices should be followed in all cases of exposure. In case of eye contact, flush with plenty of water for at least 15 min and call a physician. Emulsion-form PAMs contain hydrocarbon solvents whose vapors can cause nausea, headaches, and other symptoms. Consult the MSDS for the specific product for safety procedures before handling any PAM product.

II.B. *Spill Control.* Dispose of PAMs according to federal, state, local, and provincial regulations. Solutions of PAMs make floors and other surfaces extremely slippery. A dike should be formed around the spill area to contain as much spilled material as possible and the contained material should be shoveled, scooped, or pumped, as appropriate, into suitable disposal containers. Any remaining material should be adsorbed on vermiculite or other suitable adsorbing material and placed in

a sealed metal container for disposal. The spill area should be thoroughly washed with water only after all possible polymer has been scooped up, absorbed, or wiped up. Use of warm water is beneficial.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

This AWWA standard can be used to prepare a purchase specification but is not itself a specification because it cannot address requirements unique to the purchaser's specific situation, nor does it establish business relationships or set additive requirements (MCL or maximum-use dosage). In addition, this PAM standard does not establish physical and chemical property specifications for any one PAM product for two reasons: (1) PAMs are a broad family of products differing widely in properties and product form, and (2) physical and chemical properties of PAMs do not always relate to their performance as a flocculant in specific applications.

III.A. *Purchaser Options and Alternatives.* The following items should be provided by the purchaser.

Sec. III.A.1 through Sec. III.A.6 detail requirements that the user may consider when developing a PAM product purchase specification.

III.A.1. General Product Requirements.

III.A.1.1. Additive requirements (Sec. I.C). The following requirements should be met for additives:

1. Certification under the earlier USEPA advisory program or the current NSF/ANSI 60.

2. Compliance with USEPA Phase II Rule National Primary Drinking Water Regulations acrylamide monomer treatment technique requirements (40 CFR 141.111).

3. Approval by or certification that meets any applicable state or local requirements.

4. Whether the recommended compliance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, is to be required. If this certification is to be required, the purchaser's specifications shall read, "This material shall be certified as suitable for contact with or treatment of drinking water by an accredited certification organization in accordance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects."

III.A.1.2. Residual acrylamide monomer (Sec. I.C of the foreword, and Sec. 4.6.2, Sec. 5.7). The acrylamide monomer content of each shipment and lot of PAM shall be no greater than 0.05 percent by weight of the active polymer content based on a dose level of 1 mg/L active PAM polymer (or equivalent). Upon request, the supplier shall provide an estimate of the residual acrylamide monomer content. This estimate shall be based on the maximum concentration of residual acrylamide monomer and shall be reported as less than or equal to that concentration.

NOTE: It may not be possible for the supplier to routinely provide the precise value of the residual acrylamide monomer of each PAM shipment. Such measurements are conducted on each manufactured batch, which may be continuously added to bulk storage tanks from which shipments are continuously extracted.

III.A.1.3. Impurities (Sec. 4.6).

III.A.2. User Specific Requirements.

1. Description of application.
2. Estimated annual purchase requirements (lb [kg]).
3. Typical order size (number of containers and (lb [kg]).
4. Packaging (superbag, bag, fiber drum, pails, drum and drum size, returnable semibulk containers, nonreturnable semibulk containers, bulk by truck, bulk by rail) (Sec. 6.2).
5. Marking (Sec. 6.1).
6. Shipping (Sec. 6.2).
7. Delivery requirements (truck with a lift gate; length and coupling size of hoses needed for bulk delivery; transfer pump; allowed times of delivery; limitations on truck size or weight; sampling protocol; other).
8. Order lead time (number of days between order placement and delivery necessary if typical lead times are insufficient).
9. Affidavit of compliance (Sec. 6.3).
10. Origin of material (Sec. 5.9).
11. Shipping and billing addresses.
12. Financial terms.
13. Insurance/performance bond requirements.
14. Other user-specific requirements.

III.A.3. Product Form Requirements (Sec. I.A, Sec. 4.2, Sec. 4.3). Restricting purchase specifications to a single PAM product form (powder, emulsion, or solution) may be dictated by the capabilities of the available feeding and storage

facilities or by personal preference. This restriction, however, may eliminate consideration of the most efficacious product.

III.A.4. General Product Properties (if known) (Sec. 4.2).

1. Charge type: anionic, nonionic, cationic.
2. Charge density (mole percent):
   - Less than 1% (nonionic).
   - 1%–10% (weakly anionic or weakly cationic).
   - 10%–25% (moderately anionic or moderately cationic).
   - Greater than 25% (strongly anionic or strongly cationic).
   - Other.
3. Active polymer content: The purchaser need not specify the active polymer content until a specific product and supplier are chosen. Once chosen, the supplier should provide the percent by weight of active polymer in the product (Sec. 4.5.1).
4. Physical properties: If the purchaser knows, for example, that certain physical properties cannot be handled by the storage or feed equipment, these properties should be stated (e.g., powders: a particle size limitation; emulsions or solutions: a maximum bulk viscosity).

III.A.5. Specific Product Properties.

III.A.5.1. Minimum specifications for determining specific product properties should include visual inspection and total solids (emulsion PAM, solution PAM).

1. Visual inspection (Sec. 4.4.1, Sec. 5.3): A quick, useful qualitative test for all PAM products. This test, along with product performance in the water treatment facility, may be used to establish priorities for the urgency and extent of additional testing.
2. Total solids/percent moisture (Sec. 4.4.3, Sec. 5.4.1): Should be used as a specification as it relates to active polymer content of the PAM product and is necessary information to interpret other tests.

III.A.5.2. Other specifications that may be incorporated depending on the PAM product form include bulk Brookfield viscosity, solution Brookfield viscosity, and standard viscosity.

Bulk Brookfield viscosity of a solution PAM product is less meaningful than standard viscosity but can be a helpful specification because it is easy to determine. The bulk Brookfield viscosity of an emulsion PAM is best used to establish a viscosity above which pumping and feeding become problematic. Standard viscosity is more difficult to determine than bulk Brookfield viscosity but is a valuable specification

that can be used for all three PAM forms (emulsion, solution, powder) because it is an indirect indication of molecular weight.

1. Bulk Brookfield viscosity (Sec. 4.5.2, Sec. 5.4.3). The value of measuring Brookfield viscosity (also called bulk viscosity) of liquid PAM products as sold (as received by purchaser) depends on whether the product is in the emulsion or solution form. In either case, large variations in the bulk viscosity of the neat (as sold) liquid PAM product can be indicative of a problem. The bulk viscosity of emulsion-form PAM products do not relate to product activity and should be used as an indication of product consistency and ease of handling (pumping, storage, etc.). In the case of solution-form PAM products, bulk viscosity is related to polymer content and the polymer's relative molecular weight. Keep in mind, however, that other factors, such as conductivity, polymer charge density, and polymer structure, also can affect the bulk viscosity of solution PAM products.

2. Solution Brookfield viscosity (Sec. 4.5.3, Sec. 5.4.4). The measurement of Brookfield viscosity of a solution of any PAM product at a specific concentration is a relatively easy way to determine whether product quality variation exists. The test can be applied to any of the three forms of PAM: emulsion, solution, and powder. Many suppliers provide the Brookfield viscosity range of a specific concentration of each product. In such a case, that concentration and specific Brookfield viscosity test procedures used by the supplier should be used. Samples showing significant variation from the typical Brookfield viscosity range for that specific polymer might then be subjected to the Standard Viscosity Test.

3. Standard viscosity (Sec. 4.5.4, Sec. 5.4.5). Measurement of standard viscosity is designed to eliminate effects of conductivity, polymer charge density, and active polymer content and, therefore, to measure the relative molecular weight or volume of the polymer. The test can be applied to any of the three forms of PAM—emulsion, solution, and powder. In cases where molecular weight is important to a PAM polymer's activity in a specific water treatment application, this test can be used as a specification. Some polymer manufacturers use standard viscosity as a routine quality control test.

III.A.5.3. The following three tests are best used as investigative tools rather than as routine specifications: percent moisture, particle size distribution of powder-form PAM, and pH of an aqueous solution of PAM polymer.

1. Total solids/percent moisture (Sec. 4.4.3, Sec. 5.4.1) should be used as a specification as it relates to active polymer content. It provides important information needed to interpret other tests.

2. Particle size distribution (Sec. 4.4.2, Sec. 5.4.2) is used for powdered PAM products. The three fraction (simplified) test should usually be adequate. The three fractions, loosely defined, are (1) the largest particles that may be difficult to dissolve, (2) the typical product size range, and (3) the fines or smallest particles that may cause dusting. Powdered PAM dust that settles on a floor and becomes wet can be very slippery and, therefore, hazardous. This test is unnecessary unless there is a product dissolution problem or a dusting problem.

3. pH of a solution (Sec. 4.5.5, Sec. 5.4.6) of PAM might be helpful in confirming a quality problem, but the pH itself does not directly relate to polymer performance. For convenience, measure the pH on an aqueous solution prepared for one of the other tests such as solution viscosity. Many suppliers provide the pH range of a specific concentration of each PAM product. In that case, the solution concentration used for this test should be the same as that supplied by the manufacturer.

III.A.6. Product performance (Sec. 5.6) evaluation by way of a laboratory jar test or other performance test is essential for confirming PAM polymer activity.

It is the only means of considering possible changes in the water composition, temperature, or in the type or amount of other chemicals added with the PAM.

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

IV. Major Revisions. The major revisions made to this standard in this edition are as follows:

1. The format has been changed to AWWA standard format.
2. A day is defined as a 24-hr period.
3. A requirement for material to meet Safe Drinking Water Act and other federal requirements was added under Section 4, Requirements.
4. Sec. 5.9, Manufacturing Location Contact for Quality Control Inquiries, was added.
5. Country of origin was removed from Sec. 6.1, Markings, and replaced with a production facility identification number requirement, which may be the lot number and which is traceable through the supplier to the location of production.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer & Technical Support Group, 303.794.7711 ext. 6283, FAX 303.795.7603, or write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail standards@awwa.org.

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American Water Works Association

ANSI/AWWA B453-06
(Revision of ANSI/AWWA B454-01)

AWWA Standard

Polyacrylamide

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes polyacrylamide (PAM) for use in water supply service.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for PAM products, including physical, chemical, packaging, shipping, and testing requirements and to provide the means of developing requirements for PAM products.

Sec. 1.3 Application

This standard can be referenced in specifications for purchasing and receiving PAM products and can be used as a guide for testing the physical and chemical properties of PAM product samples. The stipulations of this standard apply when this document has been referenced and applied only to PAM used in water supply service.