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American Water Works Association

The Authoritative Resource on Safe Water®

AWWA Standard

Ferrous Sulfate

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA B402.*

I. Introduction.

I.A. *Background.* In 1903, the use of ferrous sulfate ($FeSO_4$) as a coagulant was introduced in the United States in Quincy, Ill., by William B. Bull. Lime was used in conjunction with ferrous sulfate because it aided in the oxidation and precipitation of the iron as ferric hydroxide. The first large city to use this combination was St. Louis, Mo., in 1904. "This was done in great haste in order that the visitors to the St. Louis Exposition might not be repelled by the turbid water which St. Louisans put up with since Kirkwood's recommendation for sedimentation and slow sand filtration was ruthlessly thrust aside in 1866. A permanent plant was soon built. Next among the large cities to use sulfate or iron and lime were Cincinnati, 1907, and New Orleans, 1909."†

The combination of ferrous sulfate and lime is an effective coagulant for the clarification of turbid raw waters. Ferrous sulfate is also used as a base material for the preparation of chlorinated copperas, another effective coagulant used for the treatment of some waters. Chlorinated copperas is formed by reacting ferrous sulfate ($FeSO_4 \cdot 7H_2O$) with chlorine in the ratio of 7:1. Chlorine solution is added to a solution of ferrous sulfate, usually in an enlarged pipe section that serves as a retention tank and permits complete oxidation of the ferrous sulfate to the ferric form.

Ferrous sulfate is produced as a co-product in the manufacture of certain metals and compounds, such as titanium dioxide. The principal sources providing the greatest quantity of ferrous sulfate are the sulfate process for the manufacture of titanium dioxide and the spent sulfuric acid solutions from the pickling of steel, known as pickle liquor. For shipping, solutions made from these two sources are reduced to moist and dried crystalline forms. For applications, they are dissolved and applied to water through chlorine oxidizers or with lime. Moist ferrous sulfate crystals are produced in a heptahydrate form ($FeSO_4 \cdot 7H_2O$) containing up to 10 percent free moisture and 17 to 19 percent iron. This form of ferrous sulfate is not free flowing and is generally used in large quantities for water treatment. Dried ferrous sulfate, which is produced by dehydrating moist ferrous sulfate crystals, can be obtained in two hydrate forms—heptahydrate ($FeSO_4 \cdot 7H_2O$) containing 19.5 to 20.5 percent iron and monohydrate

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† Baker, M.N., 1948. *The Quest for Pure Water*, ANSI/AWWA, Denver, Colo.

($FeSO_4 \cdot 1H_2O$) containing 29 to 31 percent iron. The practice of shipping "pickle liquor" in liquid form began in about 1965 and is still largely confined to areas within reasonable hauling distance of heavy-steel producers. Today, liquid ferrous sulfate, produced by dissolving moist or dried crystals, contains less free sulfuric acid than "pickle liquor." Because of transportation costs, it is generally sold within a 250-mi (402-km) radius of suppliers. Liquid ferrous sulfate normally contains a minimum of 5.5 percent ferrous iron or 0.5 lb of ferrous iron per gal of liquid ferrous sulfate solution (60 kg/m^3).

I.B. *History.* The first edition of this standard was prepared by the AWWA Committee on Ferrous Sulfate and was approved by the AWWA Board of Directors on June 2, 1968. Subsequent revisions to ANSI/AWWA B402 were prepared by the AWWA Standards Committee on Iron Salts, Aluminum Salts, and Related Coagulant Aids and approved by the AWWA Board of Directors on Jan. 27, 1985; Jan. 28, 1990; Jan. 22, 1995; June 11, 2000; and June 11, 2006. This seventh edition was approved on Jan. 22, 2012.

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 direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF), and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association 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.

* Persons outside the United States should contact the appropriate authority having jurisdiction.
† NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 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 Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA B402 addresses additives requirements in Sec. 4.3 of the standard. The transfer of contaminants from chemicals to processed water or to residual solids is becoming a problem of greater concern. The language in Sec. 4.3.2 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 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. *Storage and Handling Precautions.* Moist ferrous sulfate heptahydrate has a tendency to compact or cake in storage and has to be contained to prevent any leakage of liquid ferrous sulfate, necessitating increased handling requirements. The particle sizes and particle-size distributions of dried ferrous sulfate heptahydrate are important if the material is to be stored for extended periods and then fed by mechanical conveying equipment. The smaller the particles, the more readily the compound will compact or cake in storage. Caking is an impediment to feeding with conventional dry-conveying equipment. Heterogeneous particle size is also undesirable for feeding. In general, the cost of ferrous sulfate increases as particle coarseness and uniformity increase. Particle size is of little importance if the compound is to be dissolved and stored in an aqueous solution.

Ferrous sulfate monohydrate will not cake in storage if the material is maintained in a dry storage area. Because of its concentrated state, monohydrate normally takes longer to dissolve into a solution than does heptahydrate even though both forms of ferrous sulfate are equally soluble.

For safety precautions, refer to material safety data sheets (MSDS) available from the supplier or manufacturer.

II.B. *Basis for Payment.* The basis for payment when purchasing moist and dried ferrous sulfate according to this standard is the net weight of the ferrous sulfate supplied, excluding the weight of the container. One ton (907 kg) of dried ferrous sulfate heptahydrate containing 19.5 percent soluble iron is equivalent to 0.67 tons (608 kg) of dried ferrous sulfate monohydrate containing 29 percent soluble iron.

The basis for payment for liquid ferrous sulfate purchased according to this standard is the quantity equal to the number of tons equivalent to dried ferrous sulfate containing 19.5 percent soluble iron. This is calculated by determining the total soluble-iron content of the liquid ferrous sulfate and dividing the weight (in tons) of the liquid ferrous sulfate received by the ratio of 19.5 to the percentage of total soluble iron in the liquid. For example, if 10 tons (9,070 kg) of liquid ferrous sulfate are received with a total soluble-iron content of 7.5 percent, then calculate 19.5/7.5 = 2.6 and 10/2.6 = 3.85. Therefore, 3.85 tons (3,493 kg) of dried ferrous sulfate heptahydrate containing 19.5 percent total soluble iron is equivalent to 10 tons (9,070 kg) of liquid ferrous sulfate containing 7.5 percent total soluble iron.

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.

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

1. Standard used—that is, ANSI/AWWA B402, Standard for Ferrous Sulfate, of latest revision.
2. Type of ferrous sulfate to be supplied (moist heptahydrate, dried heptahydrate, dried monohydrate, or liquid).
3. Whether compliance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, is required.
4. The requirements should state if an analysis by a certified laboratory for the presence of barium, cadmium, chromium, mercury, nitrate, nitrite, selenium, antimony, berillium, cyanide, nickel, thallium, and manganese is required.
5. If liquid ferrous sulfate is required, the quantity equal to the number of tons equivalent to dried ferrous sulfate containing 19.5 percent soluble iron (Sec. II.B).
6. Details of other federal, state or provincial, and local requirements (Section 4).
7. Particle size required for dried ferrous sulfate, if different from that specified in Sec. 4.1.
8. 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, demonstrate that the product meets the standard. Failure to meet the standard or the absence of, or irregularities in, seals may be sufficient cause to reject a shipment.

9. If an analysis by a referee laboratory is required, the assignment of testing costs (Sec. 5.3.1).

10. If dried ferrous sulfate is required, the quantity, container size, type, and method of shipping (Sec. 6.2.1).

11. If liquid ferrous sulfate in tank cars is required, whether or not steam coils for heating before unloading are required (Sec. 6.2.2).

12. Whether alternative security measures have been adopted to replace or augment the security measures set out in Sec. 6.2.3 and 6.2.4.

13. Affidavit of compliance, certified analysis, or both, if required (Sec. 6.3).

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

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

1. Inclusion of a requirement for compliance with the Safe Drinking Water Act and other federal regulations.

2. Inclusion of a requirement for tamper-evident packaging (Sec. 6.2.3 and 6.2.4).

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603, write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail at standards@awwa.org.

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American Water Works Association

AWWA Standard

Ferrous Sulfate

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes ferrous sulfate ($FeSO_4$) in moist, dried, and solution (liquid) forms for the treatment of potable water, wastewater, or reclaimed water.

Sec. 1.2 Purpose

The purpose of this standard is to provide minimum requirements for ferrous sulfate, including physical, chemical, sampling, packaging, shipping, and testing requirements.

Sec. 1.3 Application

This standard can be referenced in documents for purchasing and receiving ferrous sulfate and can be used as a guide for testing the physical and chemical properties of ferrous sulfate samples. The stipulations of this standard apply when this document has been referenced and then only to ferrous sulfate used in the treatment of potable water, wastewater, or reclaimed water.