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ANSI/AWWA B506-18
(Revision of ANSI/AWWA B506-13)

AWWA Standard

Zinc Orthophosphate

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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.

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA B506.*

I. Introduction.

I.A. *Background.* Phosphate chemicals are among the few substances that can be safely and effectively used in potable water for corrosion inhibition. There are several types of phosphate inhibitors available, including zinc orthophosphate (ZOP), which was originally found to suppress iron corrosion by the Long Beach, Calif., Water Department in the 1940s.[†] Since that time, various formulations of ZOP have been used as corrosion inhibitors in potable water supplies.

ZOP can be an effective chemical inhibitor of electrolytic corrosion in iron, steel, copper, and lead, which occurs in aggressive water (with low to moderate hardness and alkalinity). ZOP was originally used to suppress colored water caused by leaching of tuberculation of iron pipe.[†] This treatment technology can be effective in waters without elevated concentrations of iron and manganese to sequester and where calcium precipitation and scaling are of minimal concern.

ZOP can also reduce asbestos fiber counts and provide protection for asbestos-cement and concrete pipe. It prevents concrete pipe deterioration in aggressive waters because the zinc interacts with cement and forms a protective zinc carbonate barrier on the surface at zinc concentrations as low as 0.2 mg/L.[‡]

ZOP formulations consist of zinc salts (sulfate and chloride) combined with orthophosphate formulated in a wide variety of zinc-to-phosphate ratios, ranging from 15:1 to 1:16.

Typically, as the zinc-to-phosphate ratio and dosage is decreased, it is necessary to increase the phosphate portion and dosage. The reverse also often occurs. The zinc proportion is provided by dissolving zinc in sulfonic, sulfuric, or hydrochloric acid and mixing that solution with sodium orthophosphate or phosphoric acid. Until the mid-1980s, the zinc proportion was more economical than the phosphate, and higher zinc-to-phosphate ratios were used. Chemical costs change relatively rapidly, and the cost value of the ratio may change.

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

† Murray, W. Bruce, *Journal AWWA*, Oct. 1970, pp. 659-662.

‡ *Internal Corrosion of Water Distribution Systems*, 2nd ed., 1996. Leroy, P. et al., Ch. 7, Cement Based Materials, p. 354, and Vik, E.A. et al., Ch. 8, Mitigation of Corrosion Effects, p. 426. Denver, Colo.: Water Research Foundation.

ZOP solutions are usually acidic, have a pH of less than 2, and are a hazardous chemical. Double containment of large storage vessels and piping as well as other chemical handling safety measures are appropriate and required.

ZOP in metal-corrosion suppression functions by two direct mechanisms: film formation and electrochemical passivation. In metal-corrosion protection, the orthophosphate provides an anodic inhibitor, and zinc films form at the cathode and provide a cathodic inhibitor. The blockage of both anodic and cathodic corrosion sites provides a double interruption of the electrochemical-corrosion reaction; that can be more effective than a single-acting inhibitor, which is typical for other phosphate or silicate chemicals.

Asbestos-cement pipe, concrete pipe, or cement linings can be protected by zinc carbonate film, which inhibits aggressive water (with a Langelier Index of less than zero) from leaching calcium and deteriorating the cement surface. There is no apparent benefit from the orthophosphate in cement protection, and other zinc formulations, including zinc chloride, can be used. However, ZOP can be a wide-ranging corrosion inhibitor for multiple types of pipe and reservoir materials of water distribution and consumer plumbing systems.

Typically, maximum ZOP dosages are limited to 5–30 mg/L, depending on supplier qualifications in testing to NSF[*]/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, in the United States. The supplier can provide operators appropriate information on certification and dosage limit of the product for use in potable water. German and other European potable water standards do not allow the use of zinc in chemicals added to potable water, and the possible use of ZOP as a corrosion inhibitor must be evaluated in each country for its intended use.

The zinc concentration is frequently limited to 0.2–2 mg/L to avoid water system secondary-contaminant limits and wastewater and effluent-discharge toxicity limits. However, as is typical for most corrosion inhibitors, it is desirable to use a passivating dose of three to five times the maintenance inhibitor dose for a month or more to reach all portions of the distribution system and initially more rapidly passivate the metal to provide the protective films.

Phosphate concentrations should typically be in the range of 0.5–2 mg/L as phosphorus (P). Sometimes, phosphate may stimulate bacteria and bioslime growths, particularly in warmer water and where chloramination disinfection is practiced. There have been instances in warmer waters in Hawaii and the southeastern United States

* NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

where elevated heterotrophic bacteria counts and other microbiological organisms have caused skin rashes in people bathing.* This possibility should always be considered when evaluating a phosphate corrosion inhibitor.

It is highly desirable to test and evaluate the effectiveness of various combinations of zinc-to-phosphate ratios and at various dosages with both instrumentation and pipe-coupon pilot plant tests.† Control tests of no inhibitor, orthophosphate without zinc, and at various pH and alkalinity values should be evaluated to select the optimum corrosion-inhibitor concentration for iron, steel, copper, lead, and cement protection. It is also quite likely that type, strategy, and temperature effects will result in use of a larger inhibitor dose in summer (warm-water temperature conditions) than in winter. Either in situ metal coupon, real-time linear polarization, or electrochemical noise measurements can optimize inhibitor dosage for changing water conditions. Inhibitor dosage control may be automated by techniques such as linear polarization or electrochemical noise sensors using programmable logic controllers (PLCs).

Alternatively, prospective vendors should be asked for initial opinions based on water quality characteristics, piping types, and conditions for zinc-to-phosphate ratios to initially try, as well as dosage recommendations. These can be changed later for more optimum conditions based upon observed results after an extended period of use.

The water characteristics that are most important when applying ZOP in corrosion protection are pH, alkalinity, hardness, and temperature. The optimum pH for use of ZOP is 7.2–7.8, and ZOP optimum dosage rates are typically lower in elevated pH and colder waters. ZOP should not be dosed into water exhibiting a pH above 8.1 to avoid possible precipitation of the zinc and undesirable turbidity or particulates in the distributed water. Much of the success with ZOP as a corrosion inhibitor has been obtained in waters exhibiting low-to-moderate hardness and alkalinity.

A recognized limitation of using a ZOP corrosion inhibitor is contribution of the zinc loading at the wastewater treatment plant and in the effluent discharged to surface waters. This is sometimes regulated to be as low as 0.5 mg/L or lower, and effluent toxicity limits may be lower than 0.1 mg/L of zinc. Another recognized effect of using a ZOP corrosion inhibitor is consumption of alkalinity and possible reduction in water pH, typically by 0.1–0.2 units. Formulations with low zinc content may provide

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* Edwards, M., B. Marshall, Y. Zhang, and Y.-J., Lee. 2005. Unintended Consequences of Chloramination Hit Home. *In* Proc. Disinfection 2005, Feb. 6-9, 2005, Mesa, Ariz. Water Environment Federation, Alexandria, Va.

† *Internal Corrosion of Water Distribution Systems*, 2nd ed., 1996. Ch. 9, Corrosion Assessment Technologies. Denver, Colo.: Water Research Foundation.

effective corrosion suppression while meeting wastewater regulations. Many different ratios are available from suppliers.

Typically, zinc is measured in the water at the end of distribution systems to provide an indication that the inhibitor dosage is sufficient to reach all portions of the piping system. Because of the corrosion inhibitor's filming effect, it is possible to have the dosage interrupted for several days to perhaps a week and not seriously compromise corrosion protection if the maintenance dose is resumed.

I.B. *History*. The first edition of ANSI/AWWA B506, Zinc Orthophosphate, was approved by the AWWA Board of Directors on Feb. 12, 2006. This edition was approved on June 11, 2018.

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). 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 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

* Persons outside the United States should contact the appropriate authority having jurisdiction.

(noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA B506 addresses additives requirements in Sec. 4.3.2 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, provincial, 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*. ZOP that is a dry solid should be stored in closed containers in a cool, dry area on concrete floors and should be protected from physical damage. Dry ZOP has an affinity for water and can easily absorb moisture, which can result in severe caking and lumping.

Liquid ZOP is generally manufactured with phosphoric acid and zinc salts. Therefore, ZOP products should be stored and handled as any typical strong acid and should be considered hazardous.

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 B506, Zinc Orthophosphate, of latest revision.
2. Quantity required.
3. Whether compliance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, is required.
4. Zinc-to-phosphate ratio ($Zn:PO_4^{3-}$) desired.
5. Details of other federal, state or provincial, and local requirements (Section 4).
6. Type of material—dry or liquid (Sec. 4.2).

7. 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.

8. 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.

9. Form of shipment—bulk or package and the type and size of container (Sec. 6.2).

10. Affidavit of compliance or certified analysis, 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:

Updates to boilerplate language in the following sections:

- Impurities (Sec. 4.3)
- Notice of Nonconformance (Sec. 5.3)
- Marking (Sec. 6.1)
- Packaging and Shipping (Sec. 6.2)

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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Zinc Orthophosphate

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes zinc orthophosphate (ZOP) corrosion inhibitor in dry and liquid forms for use in the treatment of potable water, wastewater, or reclaimed water.

Sec. 1.2 Purpose

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

Sec. 1.3 Application

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