



**American Water Works
Association**

The Authoritative Resource on Safe WaterSM

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(First Edition)

AWWA Standard

Zinc Orthophosphate



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Foreword

This Foreword is for information only and is not 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, California, Water Department in the 1940s.^{*} Since that time, various formulations of ZOP have been used as corrosion inhibitors in potable water supplies, particularly in the western United States.

ZOP can be an effective chemical inhibitor of electrolytic corrosion in iron, steel, copper, and lead, which occurs in aggressive (low to moderate hardness and alkalinity) water. ZOP was originally used to suppress colored water caused by leaching tuberculation of iron pipe.^{*} This 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 phosphate-to-zinc ratios, ranging from 16:1 to 1:15, zinc-to-phosphate.

Typically, as the zinc 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-

^{*} Murray, W. Bruce, *Jour. AWWA*, Oct. 1970, pp. 659–662.

[†] Leroy, P. et al., Chapter 7, *Cement Based Materials*, p. 354, and Vik, E.A. et al., Chapter 8, *Mitigation of Corrosion Effects*, pp. 425–439, Internal Corrosion of Water Distribution Systems, Second Edition, 1996, AWWA.

orthophosphate ratios were used. Chemical costs change relatively rapidly, and the cost value of the ratio may change.

ZOP solutions are usually acidic, have a pH of less than 2, and are a hazardous chemical. Double containment of large storage vessels, piping, and 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, which 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 minimizes aggressive (less than zero Langelier Index) water from leaching calcium and deteriorating the cement surface. There is no apparent benefit of 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 pipe and reservoir materials of water distribution and consumer plumbing systems.

Typically, maximum ZOP dosages are limited from 5 mg/L to 30 mg/L, depending on supplier qualifications of NSF^{*}/ANSI[†] 60, Drinking Water Chemicals—Health Effects, testing 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 for each country of intended use.

The zinc concentration is frequently limited from 0.2 to 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 necessary to utilize 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 passivate the metal to provide the protective films.

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