



**American Water Works
Association**

ANSI/AWWA B304-13
(Revision of ANSI/AWWA B304-08)

AWWA Standard

Liquid Oxygen for Ozone Generation for Water, Wastewater, and Reclaimed Water Systems

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AWWA Standard

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Foreword

This foreword is for information only and is not a part of ANSI /AWWA B304.*

I. Introduction.

I.A. *Background.* Oxygen (O₂) is commonly used as a feed gas for generating ozone (O₃) gas, which is subsequently used for disinfection or oxidation of water supplies. Oxygen may be generated on-site as a gas or liquid or purchased in bulk as liquid oxygen (LOX). Hundreds of water plants in the United States are using ozone for water treatment, with a majority generating ozone from purchased oxygen.

Gaseous oxygen is colorless and odorless while LOX is pale blue and odorless. Oxygen itself is not combustible, but it accelerates combustion to the point where materials, such as some types of clothing that are normally considered nonhazardous, become very flammable. Liquid oxygen may react spontaneously with petroleum products (such as gasoline, kerosene, oils, and greases) and other fuels (such as hydrogen and ethanol). Oxygen is nontoxic under most conditions of use, but LOX or cold gas will freeze tissues and can cause severe cryogenic burns. Breathing high-purity oxygen (greater than 60 percent) may produce coughs and chest pains.

LOX is normally produced through a cryogenic air separation process. This process involves compressing ambient air; cooling the air with a refrigeration unit; and removing residual water, carbon dioxide, and hydrocarbons with a molecular sieve adsorption unit. The clean, cold air is then liquefied and separated into its components, mainly oxygen and nitrogen, by distillation. Final oxygen purity can be controlled by further separating and removing trace components such as argon and krypton.

Ozone can be produced from oxygen in the air or from high-purity gaseous oxygen. This can be achieved by several methods, although the silent electrical discharge process is the most common method. Ozone is produced when a dry oxygen or air gas stream is subjected to a high-voltage/high-density electrical current, which provides the energy to drive the reaction. The oxygen-to-ozone reaction takes place between two electrodes separated by a dielectric, forming a gap across which the energy discharge occurs. Oxygen-fed ozone generators will produce more ozone for a given power input and produce higher ozone concentrations in the product gas, compared with operating on air.

* American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036.

I.B. *History.* The first edition of ANSI/AWWA B304 was approved June 12, 2005. The second edition was approved by the AWWA Board of Directors on June 8, 2008. This edition was approved on June 9, 2013.

I.C. *Purpose of Standard.* Because of the varied nature of oxygen production and feed equipment in use in the water supply industry today, it was the consensus of the AWWA Standards Committee on Oxygen that this standard should address only the recommendations for procurement of commercial LOX to be used for ozone generation, and not for other potential uses. This does not preclude any user of oxygen who produces it on-site for use in ozone production from using the analytical techniques described in this standard to determine the purity of the product produced. It was not the intention of the committee to recommend any particular means of oxygen generation or use, or to recommend an approach to design of facilities, but merely to provide a standard for the purchaser of commercially produced oxygen on the industrial market.

One of the purposes of this oxygen standard is to describe the level of quality for the oxygen source used in ozone generation systems. As such, in the event that the level of quality is outside the recommended quality standards of this document, the purchaser may advise the supplier of the ozone generation equipment of the potential nonconformance.

I.D. *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 American Water Works Association Research Foundation (AwwaRF, now Water Research Foundation) 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

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

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

ANSI/AWWA B304 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. 4.3.5 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 also 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.* The storage and handling of LOX is widespread in many industries besides the water industry. Because of this, there are many codes and design standards associated with the storage and handling of LOX. Some of these codes and standards include the following:

1. International Fire Code, latest edition, International Code Council.[†] The 2000 edition of this code included requirements applicable to LOX in chapter 27, Hazardous Materials—General Provisions; chapter 30, Compressed Gases;

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

† International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001.

chapter 32, Cryogenic Fluids; chapter 40, Oxidizers; and appendix G, Cryogenic Fluids—Weight and Volume Equivalents.

2. National Fire Protection Association (NFPA)* 55: Compressed Gases and Cryogenic Fluids Code.
3. OSHA† General Industry Occupational Safety and Health Standards, 29 CFR 1910.104—Oxygen.
4. Design standards published by the Compressed Gas Association Inc. (CGA).‡
 - a. AV-1, Safe Handling and Storage of Compressed Gases
 - b. AV-8, Characteristics and Safe Handling of Cryogenic Liquid and Gaseous Oxygen
 - c. G-4, Oxygen
 - d. G-4.1, Cleaning Equipment for Oxygen Service
 - e. P-1, Safe Handling of Compressed Gases in Containers
 - f. P-2, Characteristics and Safe Handling of Medical Gases
 - g. P-12, Safe Handling of Cryogenic Liquids
 - h. P-39, Oxygen-Rich Atmospheres
 - i. V-1, Compressed Gas Cylinder Valve Inlet and Outlet Connections
 - j. V-7.1, Standard Method of Determining Cylinder Valve Outlet Connections for Medical Gases
 - k. *Handbook of Compressed Gases*, Fourth Edition

These codes include requirements pertaining to the use of noncombustible materials and to the separation between LOX facilities and other facilities, such as public right-of-way. State and local agencies may have specific requirements with regard to oxygen systems also.

These codes and standards emphasize the need to prevent combustible or flammable materials from coming in contact with LOX or air enriched with oxygen as the result of a leak in the storage and conveyance facilities. There are many opportunities for ignition of mixtures of oxygen and combustible or flammable materials from personnel or trucks unloading LOX into the bulk storage tanks. It is important, therefore, to isolate these materials from areas where excessive oxygen can be present because

* National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

† Occupational Safety & Health Administration, 200 Constitution Avenue NW, Washington, DC 20210.

‡ Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151; <http://www.cganet.com/Publications.php>.

of unanticipated circumstances. Examples of materials that could pose a problem in oxygen-enriched environments include rags, paper towels, any wood materials, asphaltic pavement, and any oils or hydrocarbon materials in solid, liquid, or gaseous forms. Smoking must be prohibited from the general area of the LOX storage area. Finally, it is important to apply good housekeeping practices to areas where oxygen can be present in enriched quantities.

In addition to industry codes and standards, the material safety data sheets (MSDS) from liquid oxygen manufacturers should be consulted for information on hazards and safe handling precautions.

II.B. Gas Pretreatment. LOX must first be vaporized to a gaseous form prior to use for ozone generation. The vaporization step can be accomplished through the heating of LOX by ambient temperature air, ambient temperature water, or electrical energy. Once vaporized, the gaseous oxygen should be pretreated before introduction to the ozone generators. This pretreatment typically involves the addition of small quantities of nitrogen to improve ozone generation efficiency and filtering to remove particulate matter. Gaseous oxygen is typically monitored for excessive moisture content downstream of nitrogen addition to prevent problems in the ozone generator equipment.

As discussed above, it has been found that small concentrations (at least 1 percent, by weight) of nitrogen in the gaseous oxygen stream fed to ozone generators improve generator efficiency significantly. It has become common practice to introduce a small stream of compressed, dry air into the gaseous oxygen to achieve this efficiency benefit. The air must be compressed by an oil-free compressor to prevent the introduction of hydrocarbons into the oxygen stream, and the air must be dried by a desiccant dryer or similar means.

Particulate matter could enter the ozone generators from the piping or storage tank if not properly cleaned before startup or following maintenance of the system. A filtration system is necessary to remove this particulate matter prior to the ozone generators. In-line filtration may be used by the user to reduce the amount of particulates in gaseous oxygen. Filtration recommendations or specifications from the ozone generator manufacturer should be followed; however, the equipment used is typically a 1- μm nominal, 2- μm absolute filter assembly or similar installed in the system between the vaporizers and the ozone generators.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine 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 B304, Liquid Oxygen for Ozone Generation, of latest revision.
2. Whether the recommended compliance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, is required.
3. Details of other federal, state or provincial, and local requirements (Sec. 4.1).
4. Purity requirement if other than 99 percent (Sec. 4.3).
5. Whether filtration is required (Sec. 4.3.3).
6. Certified analysis report delivery requirements (Sec. 5.1).
7. Preferred sampling method (Sec. 5.2).
8. Whether the purchaser will reject product from containers or packages with missing or damaged seals. The purchaser may reject product from bulk delivery containers or packages with missing or damaged seals unless the purchaser's tests of representative samples, conducted in accordance with Sec. 5.2 and 5.3, 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. Preferred analytical method (Sec. 5.3.3).
10. Preferred method for determination of water content (Sec. 5.3.4).
11. Preferred method for determination of hydrocarbon content (Sec. 5.3.5).
12. Notice of Nonconformance (Sec. 5.4).
13. Whether the supplier of the ozone generation equipment should be notified by the purchaser if a potential condition exists of nonconformance of the LOX supply and/or shipment (Sec. 5.4).
14. Delivery method (Sec. 6.2).
15. Types of containers to be used (Sec. 6.2).
16. Whether alternative security measures have been adopted to replace or augment the security measures set out in Sec. 6.2.1.1 and 6.2.2.2.
17. If bulk shipments are specified, whether a weight certificate from a certified weigher is required in lieu of a certified liquid meter ticket (Sec. 6.2.2.1).
18. An affidavit of compliance or certified analysis, or both (Sec. 6.3), if required.
19. A certified analysis (Sec. 6.3), if required.

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

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. Added a new paragraph in the foreword giving the purchaser the option to advise the ozone equipment supplier in the event of nonconformance of the LOX supply and/or shipment (Foreword, Sec. I.C).
2. The references were updated in Foreword, Sec. II.A, Storage and Handling Precautions, and additional references for the Compressed Gas Association standards were included.
3. Sec. 2, References, was updated.
4. Sec. 4.3.3 was revised to make filtration of the liquid oxygen an option rather than a requirement to be consistent with industry practice, and an item was added to the Purchaser's Options and Alternatives in the foreword.
5. The references were updated in item 3 of Sec. 5.2.1, Liquid shipment sampling method, to reflect industry standard.
6. The references were updated in Sec. 5.3.3.1, Orsat-type meter, to reflect industry standard.
7. Sec. 5.3.6, Particulates, was moved from the body of the standard to foreword, Sec. II, Special Issues, since it is a recommendation and not a requirement.
8. Sec. 5.4, Notice of Nonconformance; Sec. 6.1, Marking; and Sec. 6.3, Affidavit of Compliance and Certified Analysis; were revised to be consistent with the recommended Standards Council boilerplate language.
9. Sec. 6.2, Packaging and Shipping, was updated.

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 email at standards@awwa.org.

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Association**

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(Revision of ANSI/AWWA B304-08)

AWWA Standard

Liquid Oxygen for Ozone Generation for Water, Wastewater, and Reclaimed Water Systems

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes liquid oxygen (LOX) 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 LOX intended for water, wastewater, and reclaimed water systems. This standard includes physical, chemical, packaging, shipping, sampling, and testing requirements.

Sec. 1.3 Application

This standard can be referenced in purchase documents for LOX and can be used as a guide for sampling and testing the physical and chemical properties of LOX samples. The stipulations of this standard apply when this document has been referenced and then only for LOX used for generation of ozone for water supply applications and in the treatment of potable water, wastewater, or reclaimed water.