ASCE STANDARD

ASCE/EWRI

2-22

Measurement of Oxygen Transfer in Clean Water

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

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PREFACE

This standard is a revision of the 1992 and 2006 standards and represents the current consensus of the ASCE Committee on Oxygen Transfer Standards after monitoring and evaluating the previous standards.

Preparation of a standard general enough to be applied to all clean water unsteady-state tests and specific enough to incorporate all essential procedures was difficult. Users of this standard must give particular attention to use of the mandatory "shall" and advisory "should" terms. For particular applications of this standard, it may be advantageous for the user to elevate certain advisory steps to the mandatory level. The body of this standard is supplemented with appendixes and commentary, both of which follow the text. The appendixes provide *mandatory* information: material that is an essential part of the standard but is too lengthy to place in the text. The commentary provides *nonmandatory* information to supplement the standard. The commentary is not a part of the standard.

Revisions to the mandatory requirements in the 2022 standard include

- Use of the nonlinear least squares estimates for parameter fitting;
- Need to correct and report results to a common TDS level (1,000 mg/L);
- Acceptance of a nitrogen gas method for deoxygenation; and
- Improved section on abbreviations, definitions, notations, and symbols.

A new commentary provides a detailed description of a supersaturated oxygen desorption method. This method may be incorporated into a future revision of the standard as an acceptable method, pending a comparison of results with existing deoxygenation methods.

It is intended that this standard be used by engineers in the preparation of specifications for compliance testing. When this is the case, the engineer should consider the costs of requiring extensive compliance testing in relation to the initial cost of the oxygen transfer system and the present worth of future operating costs.

The substance of this standard is based on recommendations made in the 1983 report, "Development of Standard Procedures for Evaluating Oxygen Transfer Devices," edited by William C. Boyle and the ASCE Oxygen Transfer Standards Subcommittee. See the primary references Brown and Baillod (1982), Paulson and Rooney (1983), Yunt and Salzman (1983), Stenstrom and Gilbert (1981), plus Boyle (1979) for background information, and Baillod et al. (1986) for a report on accuracy and precision of one method.

References for provisions are listed at the end of Chapter 9.

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ASCE acknowledges the devoted efforts of the Committee on Oxygen Transfer Standards of the Special Standards Division. This group comprises individuals from many backgrounds including consulting engineering, research, education, wastewater equipment manufacturing, government, industry, and private practice.

The contributions of the Environmental Protection Agency for workshops and for laboratory and field studies that supported the development and refinement of this standard are gratefully acknowledged.

This standard was formulated through the consensus standards process by balloting in compliance with procedures of ASCE's Codes and Standards Committee. Those individuals who currently serve on the Standards Committee and the previous chair are as follows:

James Joseph Marx, *Chair*
Michael Gerard Rieth, *Corresponding Editor*
Conrad G. Keyes Jr., *Past Chair*
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CHAPTER 1
INTRODUCTION

1.1 SCOPE

This procedure covers the measurement of oxygen transfer rate (OTR) as a mass of oxygen per unit time dissolved in a volume of water by an oxygen transfer system operating under given gas rate and power conditions. (Methods for measurement of gas rate and power are described in Appendixes A and B, respectively.) The procedure is applicable to laboratory-scale oxygenation devices with small volumes of water as well as to full-scale systems with water volumes typical of those found in the activated sludge wastewater treatment process. The procedure is valid for a wide variety of mixing conditions.

The primary result of this test is expressed as the standard oxygen transfer rate (SOTR), a hypothetical mass of oxygen transferred per unit of time at zero dissolved oxygen concentration, water temperature of 20 °C, and barometric pressure of (101.3 kPa) under specified gas rate and power conditions. The procedure is intended primarily for clean water testing to meet the requirements of Sections 5.2 and 6.3. The results can be applied to estimate OTR in process water, as described in Commentary C1.1.

Other items of interest that can be calculated are the standard aeration efficiency, or rate of oxygen transfer per unit power input, and the standard oxygen transfer efficiency; reporting items is another item of interest.

1.2 APPLICABLE STANDARDS

ASCE/EWRI Standard 2-06, as published by ASCE in Reston, Virginia (USA), has been updated by this document. *Standard Methods for the Examination of Water and Wastewater*, 23rd ed. (AWWA 2017), is mentioned where its use is needed with this standard.

1.3 ABBREVIATIONS, NOTATION, AND SYMBOLS

1.3.1 Abbreviations

DO: dissolved oxygen
EOM: engineer-owner-manufacturer
EWRI: Environmental and Water Resources Institute
HPO: high purity oxygen
HPO-AS: high purity oxygen activated sludge
HPOD: high purity oxygen desorption
MBAS: methylene blue active substance, anionic surfactant
NLLS: nonlinear least squares
OTE: oxygen transfer efficiency
OTR: oxygen transfer rate
SG: specific gravity
SI: Système Internationale (International System of Units)
TDH: total discharge head
UCLA: University of California, Los Angeles
WEF: Water Environment Federation

1.3.2 Chemical Abbreviations

$CoCl_2 \cdot 6H_2O$ cobalt chloride hexahydrate
$CoSO_4$ cobalt sulfate
Na_2SO_3 sodium sulfite
O_2 oxygen gas

1.3.3 Units

lb_f pound force
lb_f/ft^3 specific weight, pound force per cubic foot
mg/L liquid concentration, in SI units typically used in the industry
Nm^3 volume in normal cubic meters (0 °C, 101.3 kPa, 0% relative humidity)
std ft^3 volume in standard cubic feet (68 °F, 14.7 psia, 36% relative humidity)

1.3.4 Notation and Symbols

AE aeration efficiency: mass of oxygen transferred per unit power input (power may be expressed as delivered, brake, wire, or total wire), in lb/hp-h (kg/kW-h)
BOD biochemical oxygen demand, in mg/L
C DO concentration, in mg/L
$C_{\text{predicted}}$ DO value predicted using the basic oxygen transfer model, in mg/L
C^*_{scal} DO concentration in the calibration vessel, in mg/L
C^*_{sT} tabular value DO surface saturation concentration at test temperature, standard total pressure of 1.00 atm (101.3 kPa), and 100% relative humidity, in mg/L
C^*_{s20} tabular value DO surface saturation concentration at 20 °C, standard total pressure of 1.00 atm (101.3 kPa), and 100% relative humidity, in mg/L
C_{target} target DO at which supersaturation stops and oxygenated gas flow is switched to air flow, in mg/L
C_0 DO concentration at time zero, in mg/L
C^*_∞ value of steady-state DO saturation concentration as time approaches infinity, in mg/L
$C^*_{\infty 20}$ steady-state DO saturation concentration corrected to 20 °C and standard barometric pressure of 1.00 atm (101.3 kPa), in mg/L
$C^*_{\infty 20i}$ steady-state DO saturation concentration, corrected to 20 °C and standard barometric pressure of 1.00 atm (101.3 kPa), at determination point i, in mg/L
$C^*_{\infty,\text{en}}$ steady-state DO saturation concentration using oxygen-enriched air at test water temperature and local barometric pressure, in mg/L
$C^*_{\infty\text{HPO}}$ steady-state DO saturation concentration corresponding to the elevated oxygen partial pressure