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Standard Guidelines for In-Process Oxygen Transfer Testing

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Abstract:

This *Standard Guidelines for In-Process Oxygen Transfer Testing* describes several proven techniques for measuring oxygen transfer under process conditions. Nonsteady state, offgas, and inert gas tracer methods are detailed in the body of this standard, which is followed by a brief discussion of comparisons among methods. It is intended that these guidelines be used by engineers, owners, and manufacturers in evaluating the performance of aeration devices under process conditions.

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Standards

In April 1980, the Board of Directors approved ASCE Rules for Standards Committees to govern the writing and maintainance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Management Group F (MGF), Codes and Standards. The consensus process includes balloting by the balanced standards committee made up of Society members and non-members, balloting by the membership of ASCE as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding five years.

The following standards have been issued:

ANSI/ASCE 1-82 N-725 Guidelines for Design and Analysis of Nuclear Safety Related Earth Structures

ANSI/ASCE 2-91 Measurement of Oxygen Transfer in Clean Water

ANSI/ASCE 3-91 Standard for the Structural Design of Composite Slabs and ANSI/ASCE 9-91 Standard Practice for the Construction and Inspection of Composite Slabs

ANSI/ASCE 4-86 Seismic Analyis of Safety Related Nuclear Structures

Building Code Requirements for Masonry Structures (ACI530-95/ASCE5-95/TMS402-95) and Specifications for Masonry Structures (ACI530.1-95/ ASCE6-95/TMS602-95)

Specifications for Masonry Structures (ACI520-95/ ACSE6-95/TMS602-95)

ANSI/ASCE 7-95 Minimum Design Loads for Building and Other Structures

ANSI/ASCE 8-90 Standard Specification for the Design of Cold-Formed Stainless Steel Structural Members

ANSI/ASCE 9-91 listed with ASCE 3-91

ANSI/ASCE 10-90 Design of Latticed Steel Transmission Structures

ANSI/ASCE 11-90 Guideline for Structural Condition Assessment of Existing Buildings

ANSI/ASCE 12-91 Guideline for the Design of Urban Subsurface Drainage

ASCE 13-93 Standard Guidelines for Installation of Urban Subsurface Drainage

ASCE 14-93 Standard Guidelines for Operation and Maintainance of Urban Subsurface Drainage

ANSI/ASCE 15-93 Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

ASCE 16-95 Standard for Load and Resistance Factor Design (LRFD) of Engineered Wood Construction

ASCE 18-96 Standard Guidelines for In-Process Oxygen Transfer Testing

ASCE 20-96 Standard Guidelines for the Installation of Pile Foundations

ASCE 21-96 Automated People Mover Standards — Part 1

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Foreword

These guidelines for testing oxygen transfer devices in process water are the result of field testing by the ASCE Oxygen Transfer Standards Committee since about 1979. A significant portion of the early work by the Committee was supported by grants from the US Environmental Protection Agency.

Preparation of these guidelines has been difficult. Side-by-side testing of a number of methods has been used to verify reproducibility of those techniques and has led to substantial refinement in procedures and rejection of some techniques. The methods selected have proven to be most reliable under rigorous field conditions. The technology continues to remain dynamic, however, and modifications and/or new procedures are likely to occur in the future.

It is intended that these guidelines be used by engineers, owners, and manufacturers in evaluating the performance of aeration devices under process conditions. They are not intended for compliance testing of aeration devices insofar as performance under process conditions is affected by a large number of process variables and wastewater characteristics that are not easily controlled. In-process testing does provide the engineer with useful information that can be used in future design. It provides the owner with data that can be used for operation and maintenance of the aeration equipment. These procedures provide manufacturers with a useful research and development tool for their equipment development and design.

The procedures as a whole are applicable for all oxygen transfer devices in suspended growth systems. They may also be applicable to testing oxygen transfer devices in lakes and streams. They are not applicable to fixed film reactors, although modification of some of the methods might serve to provide data on these processes as well. The substance of the guidelines is based on the report, "Development of Standard Procedures for Evaluating Oxygen Transfer Devices," EPA 600/2-83-102, October 1983. Throughout this document, however, other pertinent references are provided dealing with more detail about the techniques. Section 5.0 provides a discussion on the comparison of the methods.

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Acknowledgments

The American Society of Civil Engineers acknowledges the devoted efforts of the Oxygen Transfer Standards Committee of the Codes & Standards Activity Council, Water Resources Standards Council. The Group is comprised of individuals from many backgrounds, including consulting engineering, research, education, wastewater equipment manufacturing, government, industry, and private practice.

The contributions of USEPA for workshops, laboratory and field studies that support the development and refinement of these guidelines is gratefully acknowledged.

This standard was formulated through the consensus standards process by balloting in compliance wth the procedures of the ASCE Codes and Standards Activity Council. Those individuals who serve on the Committee on Oxygen Transfer Standards are:

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American Society of Civil Engineers
Standard Guidelines for In-Process Oxygen Transfer Testing

1.0 Scope

1.1 The methods described under these standard guidelines provide several proven techniques for measuring oxygen transfer under process conditions. Non-steady state, offgas, and inert gas tracer methods are described in the body of this manual, which is followed by a brief discussion of comparisons among methods. The methods presented are considered to be well developed and provide satisfactory precision for a wide range of aeration processes in suspended growth biological systems. Because a wide range of process variables and wastewater characteristics which impact the precision (and accuracy) of these methods are difficult to control, the methods are offered as standard guidelines and are not recommended for compliance testing of aeration equipment.

2.0 Non-steady State Method

2.1 Objective This section describes a method to determine the average oxygen transfer coefficient, K_La_f, for an aeration tank under actual process conditions by measuring the DO concentration over time after a perturbation from the steady state condition. It is recommended that the pertubation be obtained using H_2O_2, instead of by changing the power level, to preserve hydrodynamics and allow higher incremental DO increases.

2.2 Theoretical basis The theoretical basis for this method is derived from consideration of a mass balance around a completely mixed aeration tank under steady state and non-steady state process conditions. The same mechanism applies for (1) O_2 transfer into wastewater, when the DO is less than the steady state equilibrium value, and (2) for O_2 stripping from the wastewater, when the DO is greater than the steady state equilibrium value. Note that this technique measures the oxygen transfer coefficient. It is not directly applicable for stripping other gases, which may have different molecular sizes and diffusion rates as well as significant gas side resistances. Kayser (1967, 1969, 1979) was the first researcher to apply this technique in testing aeration equipment under process conditions.

2.2.1 A mass balance for oxygen around a completely mixed aeration tank, as shown in Figure 1, is determined by the equation

$$QC_i - QC + K_La_f(C^*_{\infty f} - C)V = V\Delta C/\Delta t \quad (1)^\dagger$$

Dividing by V and letting $\Delta \rightarrow 0$ yields the following differential equation:

$$\frac{dC}{dt} = \frac{(C_i - C)}{\theta_h} + K_La_f(C^*_{\infty f} - C) - R \quad (2)$$

where θ_h = detention time = V/Q and Q = total flow rate = $Q_P + Q_R$.

† Symbols and nomenclature are defined in Appendix D.

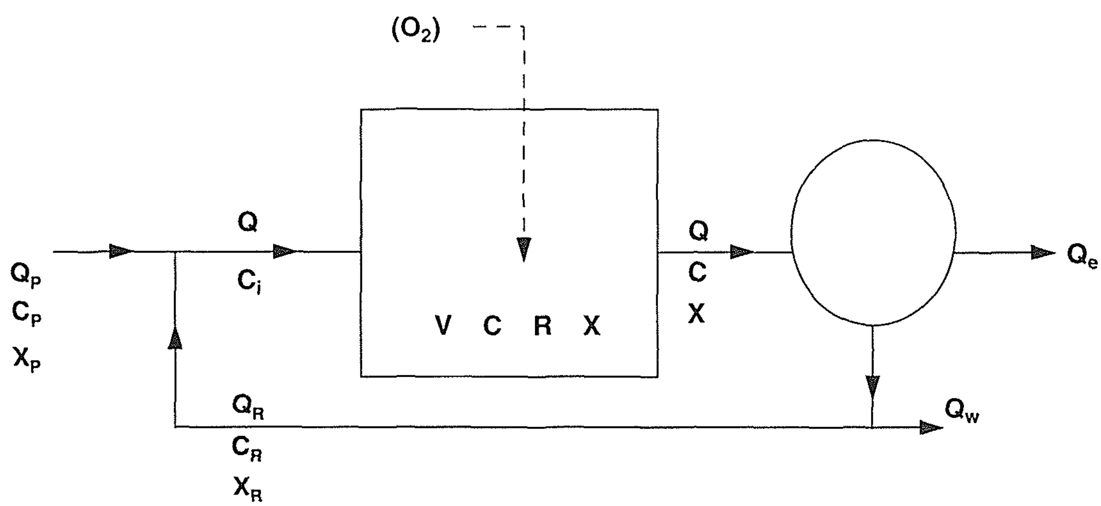

Figure 1: Schematic of a Completely Mixed System.