

**Compendium of Methods
for the
Determination of Inorganic
Compounds in Ambient Air**

Project Summary

This Project Summary is the announcement of the availability of a collection of methods for measurement of inorganic pollutants of interest in ambient air. These methods have been prepared to provide regional, state and local environmental regulatory agencies and other users with step-by-step sampling and analysis procedures for the determination of selected inorganic pollutants in ambient air. The methods comprise the *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air*, which is intended to assist those persons responsible for sampling and analysis of ambient inorganic pollutants.

Determination of pollutants in ambient air is a complex task, primarily because of the wide variety of compounds of interest coupled with the lack of standardized sampling and analysis procedures. Many inorganic compounds can be sampled and analyzed by several techniques, often with different interferences and detection limitations. This Compendium contains a set of 17 methods (in 5 categories) presented in a standardized format, with a variety of applicable sampling methods and various analytical techniques for specific classes of inorganic pollutants, as appropriate to their ambient levels and potential interferences. Consequently, this treatment allows flexibility in selecting alternatives to complement the user's background and laboratory capability. These methods may be modified from time to time as advancements are made.

This Project Summary was developed by EPA's Center for Environmental Research Information (CERI), National Risk Management Research Laboratory (NRMRL), Office of Research and Development (ORD), U.S. EPA, Cincinnati, OH, with assistance from the ORD's National Exposure Research Laboratory (NERL) at Research Triangle Park, NC. Its purpose is to announce key findings of the research project, which is fully documented in a separate report of the same title (see Project Report ordering information on the last page).

Introduction

The Clean Air Act Amendments of 1990 (CAAA of 1990) have significantly increased the responsibilities of both federal and state agency programs for evaluating and maintaining air pollutant emissions compliance. In turn, this increased responsibility has generated a need for more personnel trained to interpret, enforce, and respond to regulatory initiatives. Consequently, the Agency has restructured its technology transfer program to more effectively provide technical assistance in the form of publication of technical documents, presentations and workshops, and development of tools to assist Agency personnel in keeping their skills up-to-date so that they may efficiently cope with the many changes evolving in new programs, equipment, sampling and analytical methodology, and available enforcement tools.

Limited guidance has been available to state and local agencies or to other organizations concerned with the determination of inorganic pollutant concentrations in ambient air. As a result, state and local agencies and others responding to air pollution problems have had to develop their own monitoring strategies, including selection of monitoring methods, sampling plan designs, and specific procedures for sampling, analysis, logistics, calibration and quality control. For the most part, these procedures were based on professional judgments rather than adherence to any documented uniform guidelines. Many governmental agencies and professional or research organizations have developed ambient air monitoring methods and procedures, mostly to respond to specialized needs. But these methods and procedures have, *in general*, been neither standardized nor readily available to other agencies involved with ambient air monitoring for various pollutants.

To meet these needs, EPA's ORD, through CERI and NERL has supported technology transfer programs involving standardized, peer reviewed monitoring methods for regulatory and industrial personnel via publications of a series of methods Compendia. Other Compendia in this series, reflecting EPA's commitment to technology transfer, are:

- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA 600/4-89-017, June 1988.
- *Compendium of Methods for the Determination of Air Pollutants in Indoor Air*, EPA 600/4-90-010, April 1990.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition*, EPA 625/R-96/010b, January 1999.

These Compendia have historically assisted Federal, State, and local regulatory personnel in developing and maintaining necessary expertise and up-to-date technology involving sampling and analysis of both indoor and organic hazardous air pollutants (HAPs). The objective of this project was to develop and standardize methods for measuring inorganic pollutants of interest in ambient air and publish them in this *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air*. This fourth Compendium adds much needed methods for measurement of inorganic pollutants in ambient air to the series.

Consistent with past practices, the Compendium methods are provided as guidance only in appropriate monitoring situations. In particular, these methods are not intended to be used as specific regulatory guidance for measurement or monitoring purposes and are offered with no endorsement for suitability or recommendation for any specific application; rather, this is merely to document the methods and to make them more widely available.

Structure and Content of the Inorganic Compendium

This Compendium has been prepared to provide regional, state and local environmental regulatory agencies, as well as other interested parties, with specific guidance on the determination of selected inorganic compounds and pollutants in ambient air. A visual guide to the organization of the Inorganic Compendium is illustrated in Figure 1, while Table 1 lists the 17 methods which comprise the 5 chapters of the Compendium. The 17 methods have been compiled from the best elements of methods developed or used by various research or monitoring organizations. They are presented in a standardized format, and each one has been extensively reviewed by several technical experts having expertise in the methodology presented.

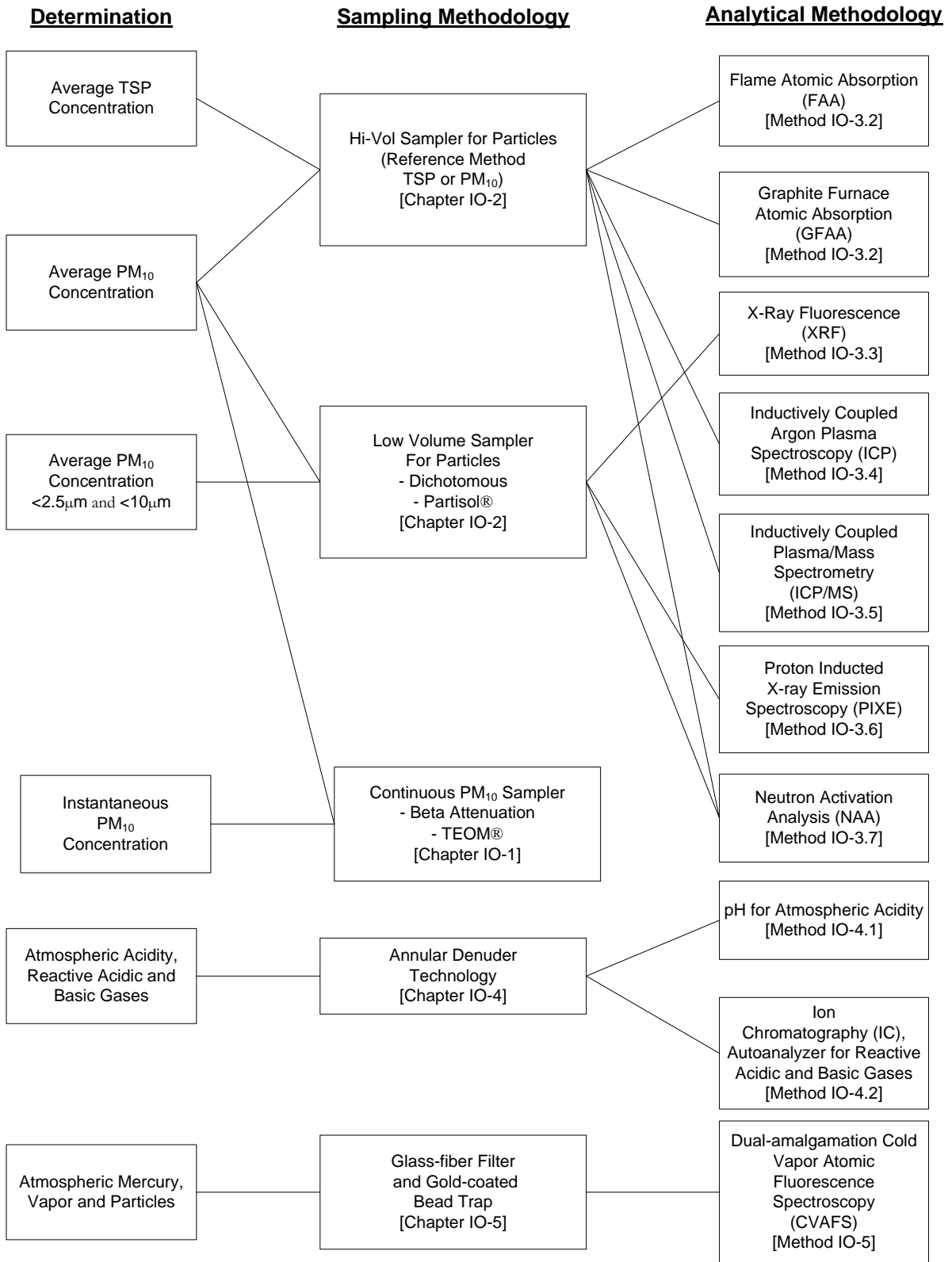


Table 1. Methods in the Inorganic Compendium

Chapter IO-1 Continuous Measurement of PM₁₀ Suspended Particulate Matter (SPM) in Ambient Air

- Method IO-1.1 Determination of PM₁₀ in Ambient Air Using the Andersen Continuous Beta Attenuation Monitor
- Method IO-1.2 Determination of PM₁₀ in Ambient Air Using the Thermo Environmental Inc. (formerly Wedding and Associates) Continuous Beta Attenuation Monitor
- Method IO-1.3 Determination of PM₁₀ in Ambient Air Using a Continuous Rupprecht and Patashnick (R&P) TEOM® Particle Monitor

Chapter IO-2 Integrated Sampling of Suspended Particulate Matter (SPM) In Ambient Air

- Method IO-2.1 Sampling of Ambient Air for Total Suspended Particulate Matter (SPM) and PM₁₀ Using High Volume (HV) Sampler
- Method IO-2.2 Sampling of Ambient Air for PM₁₀ Using an Andersen Dichotomous Sampler
- Method IO-2.3 Sampling of Ambient Air for PM₁₀ Concentration Using the Rupprecht and Patashnick (R&P) Low Volume Partisol® Sampler
- Method IO-2.4 Calculations for Standard Volume

Chapter IO-3 Chemical Species Analysis of Filter-Collected Suspended Particulate Matter

- Method IO-3.1 Selection, Preparation and Extraction of Filter Material
- Method IO-3.2 Determination of Metals in Ambient Particulate Matter Using Atomic Absorption (AA) Spectroscopy
- Method IO-3.3 Determination of Metals in Ambient Particulate Matter Using X-Ray Fluorescence (XRF) Spectroscopy
- Method IO-3.4 Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma (ICP) Spectroscopy
- Method IO-3.5 Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)
- Method IO-3.6 Determination of Metals in Ambient Particulate Matter Using Proton Induced X-Ray Emission (PIXE) Spectroscopy
- Method IO-3.7 Determination of Metals in Ambient Particulate Matter Using Neutron Activation Analysis (NAA) Gamma Spectrometry

Chapter IO-4 Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles in Ambient Air Using the Annual Denuder Technology

- Method IO-4.1 Determination of the Strong Acidity of Atmospheric Fine Particles (2.5Fm)
- Method IO-4.2 Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles

Chapter IO-5 Sampling and Analysis for Atmospheric Mercury

- Method IO-5 Sampling and Analysis for Vapor and Particle Phase Mercury in Ambient Air Utilizing Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)

The 17 specific methods, covering a variety of inorganic pollutants and compounds, are categorized into 5 chapters. Nearly all the procedures have considerable flexibility and assume that the analyst has a substantial air monitoring background and expertise. Consequently, users are responsible for preparing a specific standard operating procedure (SOP) when incorporating the Inorganic Compendium methods into their air monitoring program.

Ordering Information

The *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air*, EPA-625/R-96/010a, may be purchased in hard copy from:

National Technical Information Service (NTIS)
5285 Port Royal Road, Springfield, VA 22161
Telephone: 703-487-4650; Fax: 703-321-8547 E-mail: Info@NTIS.FEDWORLD.GOV
Internet: <http://www.ntis.gov>

➔ U.S. EPA: Office of Air Quality Planning and Standards (OAQPS)

Electronic versions of the individual Compendium (IO-) Methods are available for downloading from the “AMTIC” section of EPA’s OAQPS Technology Transfer Network via the Internet at the “AMTIC, Air Toxics” section of the TTN Web:

<http://www.epa.gov/ttn/amtic/>

Methods IO-1 to IO-5 are posted in the portable document format (PDF). The downloaded files can be read using an Acrobat Reader. Acrobat readers are available from Adobe®, free of charge, at:

<http://www.adobe.com/prodindex/acrobat/readstep.html>

and are required to read Acrobat (PDF) files. Readers are available for Windows, Macintosh®, and DOS.

➔ U.S. EPA: Office of Research and Development,
➔ Center for Environmental Research Information (CERI)

New technology transfer documents may be ordered on-line through the CERI Technology Transfer web site -- “<http://www.epa.gov/ttnrrml/>”. Once the web site has been assessed, click on the publication list and follow the menu-driven ordering instructions.

Acknowledgments

The *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air* (EPA/625/R-96/010a) was prepared under Contract No. 68-C3-0315, Work Assignments Nos. 2-10 and 3-10, by Midwest Research Institute (MRI), as a subcontractor to Eastern Research Group, Inc. (ERG), and under the sponsorship of the U.S. Environmental Protection Agency (EPA). Final revisions were performed by Science Applications International Corporation (SAIC) under Contract No. 68-C7-0011, W.A. 1-82. Justice A. Manning, John O. Burckle, and Scott Hedges, Center for Environmental Research Information (CERI), and Frank F. McElroy, National Exposure Research Laboratory (NERL), all in the EPA Office of Research and Development, were responsible for overseeing the preparation of the Compendium. Further support was provided by other members of the Compendia Workgroup, which included:

- John O. Burckle, U.S. EPA, ORD, NRMRL, Cincinnati, OH
- James L. Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Michael Davis, U.S. EPA, Region 7, Kansas City, KS
- Joseph B. Elkins, Jr., U.S. EPA, OAQPS, Research Triangle Park, NC
- Robert G. Lewis, U.S. EPA, ORD, NERL, Research Triangle Park, NC
- Justice A. Manning, U.S. EPA, ORD, Cincinnati, OH
- William A. McClenny, U.S. EPA, ORD, NERL, Research Triangle Park, NC
- Frank F. McElroy, U.S. EPA, NERL, RTP, NC
- Heidi Schultz, ERG, Lexington, MA
- William T. "Jerry" Winberry, Jr., EnviroTech Solutions, Cary, NC

**COMPENDIUM OF METHODS
FOR THE
DETERMINATION OF INORGANIC
COMPOUNDS IN
AMBIENT AIR**

U. S. Environmental Protection Agency
Office of Research and Development
Center for Environmental Research Information
National Risk Management Research Laboratory
Cincinnati, Ohio 45268

DISCLAIMER

The information in this document has been compiled wholly or in part by the United States Environmental Protection Agency (EPA) under Contract No. 68-C3-0315, W.A. 2-10 to Eastern Research Group (ERG). The work was performed by Midwest Research Institute (MRI) under subcontract to ERG. Final revisions were performed by Science Applications International Corporation (SAIC) under Contract No. 68-C7-0011, W.A. 1-82. It has been subjected to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Acknowledgments

These Methods were prepared for publication in the *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air* (EPA/625/R-96/010a), which was prepared under Contract No. 68-C3-0315, WA No. 2-10, by Midwest Research Institute (MRI), as a subcontractor to Eastern Research Group, Inc. (ERG), and under the sponsorship of the U. S. Environmental Protection Agency (EPA). Final revisions were performed by Science Applications International Corporation (SAIC) under Contract No. 68-C7-0011, W.A. 1-82. Justice A. Manning, John O. Burckle, and Scott Hedges, Center for Environmental Research Information (CERI), and Frank F. McElroy, National Exposure Research Laboratory (NERL), all in the EPA Office of Research and Development, were responsible for overseeing the preparation of this Compendium. Other support was provided by the following members of the Compendia Workgroup:

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- Robert G. Lewis, U.S. EPA, NERL, RTP, NC
- Justice A. Manning, U.S. EPA, ORD, Cincinnati, OH
- William A. McClenny, U.S. EPA, NERL, RTP, NC
- Frank F. McElroy, U.S. EPA, NERL, RTP, NC
- William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

These Methods are the result of the efforts of many individuals. Gratitude goes to each person involved in the preparation and review of this methodology.

Chapter IO-1: CONTINUOUS MEASUREMENT OF PM₁₀ SUSPENDED PARTICULATE MATTER (SPM) IN AMBIENT AIR

Method IO-1.1: Determination of PM₁₀ in Ambient Air Using the Andersen Continuous Beta Attenuation Monitor

Authors: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC
 Stephe Edgerton, Midwest Research Institute, Cary, NC

Peer Reviewers:

- Richard Shores, Research Triangle Institute, RTP, NC
- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- Charles Rodes, Research Triangle Institute, RTP, NC
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Danny France, U.S. EPA, Region 4, Athens, GA
- David Harlos, Environmental Science and Engineering, Gainesville, FL
- Jim Tisch, Graseby, Village of Cleves, OH
- Justice Manning, U.S. EPA, Cincinnati, OH
- William Bope, South Coast Air Quality Management District, Diamond Bar, CA
- Femi Durosinmi, Clark County Health District, Las Vegas, NV
- Rob Ford/Tom Merrifield, Andersen, Atlanta, GA
- Bill Vaughan, Environmental Solutions, St. Louis, MO
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-1.2: Determination of PM₁₀ in Ambient Air Using the Thermo Environmental Instruments (formerly Wedding and Associates) Continuous Beta Attenuation Monitor

Authors: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC
Stephe Edgerton, Midwest Research Institute, Cary, NC

Peer Reviewers:

- Rick Taylor, Missouri Department of Natural Resources, Jefferson City, MO
- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Charles Rodes, Research Triangle Institute, RTP, NC
- Danny France, U.S. EPA, Region 4, Athens, GA
- David Harlos, Environmental Science and Engineering, Gainesville, FL
- Jim Tisch, Graseby, Cleves, OH
- Al Wehr, Texas Natural Resource Conservation Commission, Austin, TX
- Richard Shores, Research Triangle Institute, RTP, NC
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-1.3: Determination of PM₁₀ in Ambient Air Using a Continuous Rupprecht and Patashnick (R&P) TEOM® Particle Monitor

Authors: Erich Rupprecht, Rupprecht and Patashnick, Albany, NY
William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Charles Rodes, Research Triangle Institute, RTP, NC
- Danny France, U.S. EPA, Region 4, Athens, GA
- David Harlos, Environmental Science and Engineering, Gainesville, FL
- Jim Tisch, Graseby, Cleves, OH
- Michael B. Meyer, Rupprecht and Patashnick, Albany, NY
- Richard Shores, Research Triangle Institute, RTP, NC
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Chapter IO-2: INTEGRATED SAMPLING OF SUSPENDED PARTICULATE MATTER (SPM) IN AMBIENT AIR

Method IO-2.1: Sampling of Ambient Air for Total Suspended Particulate Matter (SPM) and PM₁₀ Using High Volume (HV) Sampler

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Margaret Zimmerman, Texas Natural Resource Conservation Commission, Austin, TX
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-2.2: Sampling of Ambient Air for PM₁₀ Using an Anderson Dichotomous Sampler

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Margaret Zimmerman, Texas Natural Resource Conservation Commission, Austin, TX
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-2.3: Sampling of Ambient Air for PM₁₀ Concentration Using the Rupprecht and Patashnick (R&P) Low Volume Partisol® Sampler

Author: Erich Rupprecht, Rupprecht and Patashnick, Albany, NY

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Neil Olsen, Utah Department of Health, Salt Lake City, UT
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-2.4: Calculations for Standard Volume

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

**Chapter IO-3: CHEMICAL SPECIES ANALYSIS OF FILTER-COLLECTED
SUSPENDED PARTICULATE MATTER**

Method IO-3.1: Selection, Preparation, and Extraction of Filter Material

Authors: Avie Mainey, Midwest Research Institute, Kansas City, MO
William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Dewayne Ehman, Texas Natural Resource Conservation Commission, Austin, TX
- Gary Wester, Midwest Research Institute, Kansas City, MO
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

**Method IO-3.2: Determination of Metals in Ambient Particulate Matter Using Atomic
Absorption (AA) Spectroscopy**

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Jim Cheney, U.S. Army Corps of Engineers, Omaha, NE
- Eric Prestbo, Frontier GeoScience, Seattle, WA
- Anne M. Falke, Frontier GeoScience, Seattle WA
- Gary Wester, Midwest Research Institute, Kansas City, MO
- Margaret Zimmerman, Texas Natural Resource Conservation Commission, Austin, TX
- Doug Duckworth, Lockheed-Martin Energy Research, Oak Ridge, TN
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

**Method IO-3.3: Determination of Metals in Ambient Particulate Matter Using X-Ray
Fluorescence (XRF) Spectroscopy**

Authors: Bob Kellog, ManTech, RTP, NC
William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- Roy Bennet, U.S. EPA, RTP, NC
- Charles Lewis, EPA, RTP, NC
- Ray Lovett, West Virginia University, Morgantown, WV

- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-3.4: Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma (ICP) Spectroscopy

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- Dewayne Ehman, Texas Natural Resource Conservation Commission, Austin, TX
- David Harlos, Environmental Science and Engineering, Gainesville, FL
- Doug Duckworth, Lockheed-Martin Energy Research, Oak Ridge, TN
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-3.5: Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)

Author: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC

Peer Reviewers:

- Doug Duckworth, Lockheed-Martin Energy Research, Oak Ridge, TN
- David Brant, West Virginia University, Morgantown, WV
- Jiansheng Wang, Midwest Research Institute, Kansas City, MO
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-3.6: Determination of Metals in Ambient Particulate Matter Using Proton Induced X-Ray Emission (PIXE) Spectroscopy

Authors: J. William Nelson, Florida State University, Tallahassee,
FL C Thomas Lapp, Midwest Research Institute, Cary,
NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- John Glass, SC Department of Health and Environmental Control, Columbia, SC
- David Harlos, Environmental Science and Engineering, Gainesville, FL
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-3.7: Determination of Metals in Ambient Particulate Matter Using Neutron Activation Analysis (NAA) Gamma Spectrometry

Author: Jack Weaver, North Carolina State University, Raleigh, NC

Peer Reviewers:

- David Brant, National Research Center for Coal and Energy, Morgantown, WV
- Ron Fleming, Department of Nuclear Engineering, University of Michigan, Ann Arbor, MI
- Joseph Lambert, Raleigh, NC
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Chapter IO-4: DETERMINATION OF REACTIVE ACIDIC AND BASIC GASES AND STRONG ACIDITY OF ATMOSPHERIC FINE PARTICLES IN AMBIENT AIR USING THE ANNULAR DENUDER TECHNOLOGY

Method IO-4.1: Determination of the Strong Acidity of Atmospheric Fine-Particles (<2.5 • m)

Authors: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC
Thomas Ellestad, U.S. EPA, RTP, NC C Bob Stevens, U.S. EPA, RTP, NC

Peer Reviewers:

- Delbert Eatough, Brigham Young University, Provo, UT
- Shere Stone, University Research Glassware Corp., Chapel Hill, NC
- Petros Koutrakis, Harvard School of Public Health, Boston, MA
- J. Waldman, Robert Wood Johnson Medical School, New Brunswick, NJ
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Method IO-4.2: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles (<2.5 • m)

Authors: William T. “Jerry” Winberry, Jr., EnviroTech Solutions, Cary, NC
Thomas Ellestad, U.S. EPA, RTP, NC C Bob Stevens, U.S. EPA, RTP, NC

Peer Reviewers:

- Delbert Eatough, Brigham Young University, Provo, UT
- Shere Stone, University Research Glassware Corp., Chapel Hill, NC
- Petros Koutrakis, Harvard School of Public Health, Boston, MA
- J. Waldman, Robert Wood Johnson Medical School, New Brunswick, NJ
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Chapter IO-5: SAMPLING AND ANALYSIS FOR ATMOSPHERIC MERCURY

Method IO-5: Sampling and Analysis for Vapor and Particle Phase Mercury in Ambient Air Utilizing Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)

Authors: Gerald Keeler, University of Michigan, Ann Arbor, MI
Jim Barres, University of Michigan, Ann Arbor, MI
Matt Landis, U.S. EPA, RTP, NC

Peer Reviewers:

- Susan Kilmer, Michigan Department of Natural Resources, Lansing, MI
- Eric Prestbo, Frontier GeoSciences, Seattle, WA
- Anne M. Falke, Frontier GeoSciences, Seattle, WA
- Jamie Brown, Supelco Inc., Bellefonte, PA
- Alan Zaffiro, International Technology Corporation, Cincinnati, OH
- Dr. Matt Landis, U.S. EPA, NERL, RTP, NC
- Lauren Drees, U.S. EPA, NRMRL, Cincinnati, OH

Cover

APTI 435: ATMOSPHERIC SAMPLING COURSE

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FOREWORD

The U. S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and ground water; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

Measurement of inorganic pollutants in ambient air is often difficult, in part because of the variety of inorganic substances of potential concern, the variety of potential techniques for sampling and analysis, and lack of standardized and documented methods. This Compendium is one of three Compendia of methods which provide documented and technically reviewed methodology for determining concentrations of selected pollutants of frequent interest in ambient and indoor air. The methods contained in this Compendium provide sampling and analysis procedures for a variety of inorganic pollutants and suspended particulate matter in ambient air. As with the previous Compendia methods, these methods are provided only for consideration by the user for whatever potential applications for which they may be deemed appropriate. In particular, these methods are not intended to be associated with any specific regulatory monitoring purpose and are offered with no specific endorsement for fitness or recommendation for any particular application, other than for an attempt at standardization.

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E. Timothy Oppelt, Director
National Risk Management Research Laboratory