



This chapter will take approximately 0.25 hours to complete.

An Introduction to Atmospheric Sampling

OBJECTIVES

Terminal Learning Objective

At the end of this chapter, the student will be able to explain the purpose of atmospheric sampling and describe a typical sampling train design.

Enabling Learning Objectives

- 1.1 Explain the purpose of atmospheric sampling.
- 1.2 Describe a typical sampling train design.

1.1 Introduction

The purpose of an Air Pollution Control Program is to protect human health and welfare. Evaluating the success of Air Pollution Programs is dependent on the availability of accurate data on the ambient concentrations of air pollutants (i.e. air quality). National Ambient Air Quality Standards (NAAQS) have been established by the EPA for six criteria pollutants -- sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter, and lead. Such standards establish maximum allowable contaminant concentration levels in the ambient air. In order to determine compliance with the NAAQS, the ambient air must be sampled or monitored on a continuous or semi-continuous basis. This is accomplished by a national network of air monitoring stations. EPA has established and requires specific sampling or monitoring methods to be used for the determination of compliance with the NAAQS. These can be found in 40 CFR Part 50 Appendices A through N. In addition to sampling/monitoring for NAAQS, there is a need to evaluate the ambient air for other categories of pollutants, such as air toxics and compounds that contribute to visibility impairment and acid deposition, to adequately protect human health and welfare. Sampling and analytical procedures for the determination of these ambient air contaminants are not as well defined.

The sampling/monitoring method employed may be described as *manual* or *automated*. A *manual method* requires two distinct steps: sample collection followed by sample analysis, at which time the contaminant concentration is determined. The contaminant may be either separated from the sample gas stream during the sampling process, as is often done when collecting suspended particulate matter (SPM), such as PM_{2.5}, on a filter, or a “whole air” sample may be collected without contaminant separation from the sample gas. The taking of a “whole air” sample is one of the primary methods for sampling for volatile organic compounds in ambient air. In either case the concentration of the contaminant is not determined in real time. In fact, the sample may not be analyzed for days or

weeks after it has been collected. Conversely, *automated methods* employ instruments which are capable of performing the sampling and analysis of the contaminant of interest in real or near-real time. These instruments provide a direct readout of the contaminant concentration on a continuous or semi-continuous basis and are generally referred to as ambient *monitors*. Instruments which collect the contaminant of interest, but require the sample to be analyzed subsequent to collection, are referred to as *samplers*.

This manual primarily focuses on methods and devices used to accurately collect a representative ambient air sample and accurately quantify the volume of gas sampled. The emphasis is on sampling techniques with limited discussion on ambient monitoring. Refer to EPA Course 464, Analytical Methods for Air Quality Standards, for more details regarding ambient monitoring.

1.2 Sampling Train Design

Most atmospheric sampling techniques make use of a sampling train similar to the block diagram in Figure 1-1. Air containing the pollutant of interest enters the sampling train and passes through a sample collection device. This device either physically or chemically removes the pollutant from the air stream, holds the polluted air for later analysis, or allows the pollutant to be analyzed simultaneously with the collection. In addition, a “whole air” sample may be collected in a specially designed and prepared canister or inert sampling bag for later analysis. Ideally, only the pollutant of interest is collected. However, this is seldom the case. Consequently, interferences must be considered when measurements are made.

Many sampling techniques use collection devices that remove the pollutant from the air for later analysis. Wet chemical methods, such as the pararosaniline method for sulfur dioxide (SO₂), remove the pollutant from the air and hold the pollutant by means of a chemical reaction for later analysis. In the pararosaniline method, the sample collection device is a bubbler containing an absorbing reagent. Sampling methods, such as Method TO-1 for the Determination of VOCs in Ambient Air, remove the pollutant from the sampled air and retain it by means of physiochemical forces on the adsorbant’s surface for subsequent analysis. In this method, the collection device is a cartridge which contains an adsorbent resin material (i.e., Tenax®). The federal reference method for particulate matter sampling of PM_{2.5} uses a filter as the sample collection device. In either case, the pollutant is held by the collector for later analysis by a contaminant detector. (The contaminant detector in the pararosaniline method is a spectrophotometer; for the VOC method, it is a gas chromatography coupled with a mass spectrometry detector; and for particulate matter sampling, it is a gravimetric balance.)

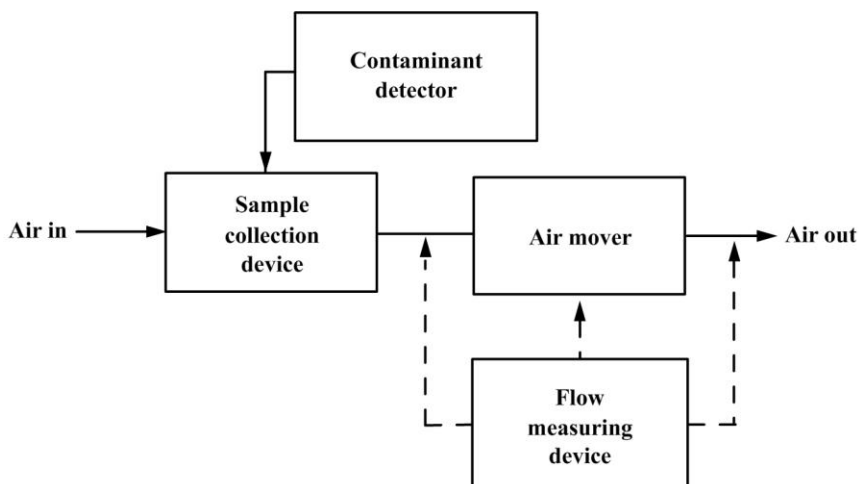


Figure 1-1. Typical sampling train.

Instrumental methods such as chemiluminescence for nitrogen dioxide (NO₂) and ozone (O₃) combine the sample collector and the contaminant detector into one device.

Some methods of air sampling collect a volume of polluted air for later analysis. These methods, generally referred to as “whole air” sampling, usually make use of grab or integrated sampling using containers made of stainless steel (e.g., passivated canisters), glass, or pliable plastics (e.g., Mylar®, Tedlar®, Teflon®, aluminized PVC). Many factors are important in considering what material should be used when grab sampling; many uses have been found for plastic bags. In this type of sampling, the plastic bag, stainless steel container, or glass container is the sample collection device. Contaminant detection is usually accomplished by instrumental analysis. Sampling methods, such as Method TO-14A for the Determination of VOCs in Ambient Air, collect a “whole air” sample of ambient air into a pre-evacuated passivated canister. The sample is drawn through a sampling train comprised of components that regulate the rate and duration of sampling. In this case, the collection device is the canister which is passivated to minimize chemical or physical changes to the sample prior to analysis.

Mechanisms used to move air through the sample collection device and measure the quantity of air are integral parts of sampling trains. Air movers are usually motor-driven pumps. When motor-driven pumps are not practical, ejectors, displacement methods, and evacuated flasks can be used. Some typical flow measuring (or controlling) devices for sampling are rotameters, mass flow meters, mass flow controllers, and critical and subcritical orifices. It is often necessary to determine how long an air mover has pulled a certain flow rate to determine the volume sampled (volume = flow rate × time); therefore, the sampling time is recorded. Placement of the flow measuring device is dependent on what device is used. Air movers and flow measuring devices are usually placed after sample collection devices to avoid contamination of the air stream.

Materials used in a sampling train (at least to as far as the collector) must be sufficiently inert to the pollutant of interest so as not to interfere with collection. If the air mover and flow measuring device must be placed before the collection step, then parts of those devices contacting the air stream must be inert. Glass, Teflon[®], and stainless steel are generally considered to be nonreactive. Hence, these materials have been used extensively in sampling train construction. However, the materials listed as being generally nonreactive can become reactive if used to sample the wrong environment. For instance, glass could not be used if a sampling train were being built to monitor hydrofluoric acid. Even if a material is considered nonreactive, significant wall loss can occur if sampling lines are too long.

Interference with the measurement of an air pollutant is not the only consideration important to the selection of sampling train materials. Care must be taken to protect sampling train components from damage caused by the sampled air or products of the measurement system. If a rubber diaphragm pump is to be used in conjunction with an analyzer that measures nitrogen oxides by the reaction of nitric oxide (NO) with ozone (O₃), then a charcoal filter must be used before the pump to remove excess ozone. If ozone is allowed to contact the rubber diaphragm of the pump, the rubber will deteriorate. Other sampling train components that usually need protection are mass flow controllers and small orifice meters. A filter and moisture trap is placed in front of the device to prevent it from becoming clogged or damaged.

Air sampling is becoming more important in recent years due to research that demonstrates the health effects associated with even small quantities of air toxics in the air, promulgation of air toxic regulations by state air pollution agencies, and improvements in analytical techniques which allow ever-increasingly smaller quantities of pollutants to be detected at a reasonable cost.

In order to collect a representative sample from the ambient air, it is necessary to measure ambient air and sample gas parameters, such as temperature, pressure, humidity, gas composition, and flow rate. The importance of these parameters and how they are used will be discussed in detail in Chapter 2 of this manual.

The topics discussed in subsequent chapters include principles of sampling for gases and particles in ambient air, as well as specific methods and instruments for gas and particle sampling, principles of operation and proper application of gas measuring devices, selection and operation of gas movers, specific methods and sampling concerns for air toxics, and quality control and quality assurance concepts.

References

- Schuette F. 1967. Plastic bags for collection of gas samples. *Atmospheric Environment* 1:515-519.
- U.S. Environmental Protection Agency (EPA). 1979 Jul 1. 40 CFR Pt. 50.
- U.S. Environmental Protection Agency (EPA). 1979 Jul 1. 40 CFR Pt. 51.
- U.S. Environmental Protection Agency (EPA). 1977 June. Air monitoring strategy for state implementation plans. EPA 450/2-77-010.
- U.S. Environmental Protection Agency (EPA). Air trends [Internet]. Cited 2008 May 6. Available from: <http://www.epa.gov/oar/airtrends>
- U.S. Environmental Protection Agency (EPA). Toxic air pollutants: about air toxics [Internet]. Cited 2008 May 6. Available from: <http://www.epa.gov/oar/toxicair/newtoxics.html>
- Wight G. 1994. *Fundamentals of air sampling*. Boca Raton (FL): CRC Press.