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Analytical Instruments for Environmental Preservation Programs

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Feature Review

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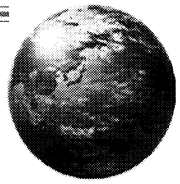

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Abstract

Human societies have succeeded in gaining material wealth, but as we approach the 21st century the current generation faces one critical issue: the preservation of the irreplaceable global environment for future generations. Horiba seeks to contribute to this cause by providing analysis systems and technology developed through long experience in this field. This paper reviews Horiba's environmental instrument products and technology, as a reference for technicians in these fields.

1. Introduction

For many thousands of years, human beings survived by respecting the balance of nature in the air, the water, and on land. In the long course of human history, it has only become apparent in the last couple of decades that human activity has disturbed this delicate balance. And it is the responsibility of the current generation to solve these environmental problems. Changes in the concentration of substances that make up the environment and introducing impurities, however slight, can disrupt the balance of the ecosystem. Moreover, most of these changes cannot be detected by the five human senses. This is the main reason why analyzer technology is demanded for preserving and monitoring the global environment. While there are numerous techniques for analyzing the environment, not all can be used effectively for the purpose of environmental preservation. To apply an analytical instrument to environmental preservation, the optimal analytical technique must be selected based on its performance and operational capability, to improve it into an economical and practical product. Horiba has made a major effort to do just this, applying its analyzer technology to the development of systems for environmental measurement. Global environmental preservation requires analyzers for a wide range of tasks, from accurately assessing the causes of environmental problems and checking the ambient conditions, to handling process management at the source of the occurrence and ensuring compatibility with regulations. The technology applied to analyzers differs depending on whether the measurement subject is the air quality, water quality, or a solid object. Moreover, there is today a wide diversity of needs in environmental analysis. Industrialized countries require analyzers able to measure a wider range of harmful substances in extremely minute quantities, while countries under development need simpler analyzers at a reasonable cost for their development. Analyzers are also now being used in the fields of energy conservation and recycling of materials[1]. This paper describes Horiba's environment-related products and technologies developed for the purpose of environmental preservation.

2. Analytical Systems Used at the Source Emission

2.1 Measurement of Stack Emissions

The stack gas from thermoelectric power plants and chemical plants, so-called "stationary sources," contains sulfur dioxde (SO_2), nitorogen oxide (NOx), and other substances harmful to the environment. For this reason, many countries require such facilities to continuously monitor their emissions of these substances, and to make every effort to reduce them. Horiba analyzers using non-dispersive infrared absorptiometry (NDIR), chemiluminescence detection (CLD), magnetopneumatic analysis, and other technologies are widely used at such facilities. At denitrification and desulfurization plants, these stack gas analyzers are used to monitor the concentrations of SO_2, NOx, ammonia (NH_3), while at cogeneration plants and in the combined cycle of power generating plant, they are applied to the continuousmeasurement of carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2) concentrations for controling combustion and improving energy efficiency. Even highway tunnels, which are another type of enclosed space with accumulated automotive emissions, use Horiba analyzers, the APTA series of CO analyzer for tunnels. The analyzer monitors CO concentration for sufficient ventilation, and transmits a signal to additional pumps which evacuate the polluted air instantly from the tunnel if the CO reading exceeds the safety level.

In all these fields, Horiba's analyzers allow automatic and continuous measurements of high accuracy and stability, and are built to withstand the harsh environment at factory sites with minimal and easy maintenance. Moreover, these analyzers also feature an optimal sample system for each plant, and include Horiba's unique cross-flow modulation analyzers. In the ENDA series of stack gas analysis systems[2], for example, the SO_2 instrument requires a cell length of only 20 to 30 mm, yet can detect changes as small as a few parts-per-million and provides stable measurement free from zero drift. **Table 1** shows the detectable gases and applications for Horiba's stack gas analysis systems for stationary sources.

Table 1 Detectable Gases and Features of the Horiba Exhaust Gas Analyzer for Source Emission

Product	Detectable Components and Principles	Applications and Features
ENDA-600 Series Stack Gas Analysis Systems	NOx, CO_2, CO: Cross-modulation system, NDIR O_2: Magnetopneumatic method	Analysis of exhaust gas from general-purpose boilers and waste incinerator plants; compact, low-cost, and maintenance-free
ENDA-1000(P) Series Stack Gas Analysis Systems	SO_2, NOx, CO_2, CO: NDIR O_2: Magnetopneumatic method	Analysis of exhaust gas from small boilers and waste incinerators; compact for loading into a vehicle for easy mobile measurement
ENDA-2000 Series Stack Gas Analysis Systems	NOx, CO_2, CO: Cross-modulation system, NDIR O_2: Magnetopneumatic method	Combustion control of thermoelectric power plants and analyzer self-diagnosis function
ENDA-C2000 Ambient NH3 Stack Gas Analyzer	Cross-modulation system chemiluminescence method	Continuous monitoring of functional deterioration of catalysts in ammonia dry-denitration devices
APTA-2000 CO Analyzer for Tunnels	Cross-modulation system NDIR	Monitoring of trace CO concentrations in tunnels; easy maintenance in a confined installation space

2.2 Measurement of Motor Exhaust Gas

Motor exhaust gas is a major source of air pollution in cities and surrounding areas. Vehicles are referred to as mobile sources because they are not static. Two of the major measures for reducing the impact of vehicles on the environment require accurate testing systems: prohibiting or restricting the sale of new cars whose emission levels exceeds the regulation limits as tested under typical driving modes; and regular testing of the exhaust levels for cars in use. Horiba offers analysis systems for both these applications.

(1) Motor Exhaust Gas Analysis System

This analysis system for testing motor exhaust gas consists of a chassis dynamometer for reproducing driving conditions in the laboratory, a constant volume sampler for measuring masses of pollutants in the exhaust gas, analyzers for the components, a data processing system, and other accessory equipment[3,4]. Developed and manufactured by Horiba, this system is used by major automobile manufacturers as well as testing and research agencies around the world. Horiba also designs and builds emission testing facilities, including the laboratory and peripheral equipment.

(2) Analysis System for Engine Research

There has been a growing demand recently for more precise analysis of combustion conditions for developing high-efficiency, low-emission engines. Responding to this need, Horiba has developed the MEXA-1000 series, specially designed to measure changes of the combustion gases inside the engine with a response time of 2-millisecond[5]. Engine developers, along with a wide range of others involved in engine research and development, such as catalyst and fuel manufacturers, have also been demanding systems that can measure in real-time exhaust gas components present only in minute quantities. Horiba's FTIR motor emission analyzer and soft ionization vehicle emission mass spectrometer[5] are helping to meet this demand.

Together, these testers enable the continuous measurement of acetaldehyde, benzene and other hazardous air pollutants (HAP).

(3) Portable Emission Analyzer for Periodic Inspection of Vehicles in Use

Horiba supplies its MEXA-J series of compact analyzers[6] around the world for testing levels of CO, hydrocarbon (HC), and other substances in the emissions of actual vehicles in daily use [6]. These analyzers can be set up at service stations and automobile inspection sites. Today, Horiba emission analyzers are used not only for automobiles, but also for ships, and aircraft engines and a wide range of related fields.

2.3 Measurement of Factory and Household Effluent

Horiba's pH meters, oxidization reduction pootential (ORP) meters, dissolved oxygen meters, conductivity meters, and turbidity monitors are widely used for the management and monitoring of effluent from factories, and household waste water. Horiba's OPSA organic pollutant monitor is also used for continuous monitoring of the concentration of total organic substances at effluent outlets. This monitor is based on the ultraviolet absorption characteristics of organic substances and employs cell length modulation technique to obtain stable, continuous measurement. Measurements taken with the OPSA system have proven to correspond closely to chemical oxygen demand (COD) values, and this monitor has been widely adopted in water quality programs in Japan for the regulation of total emissions. At sea as well,

systems for effluent measurement are required. The International Maritime Organization restricts the leakage of oil from ships and vessels to protect the maritime environment. The Horiba OCMA series[7] of infrared absorption measurement systems is widely used in this field for its ability to measure oil concentrations in water at the parts-per-million level far below what can be detected with the naked eye.

3. Monitoring Environmental Conditions

3.1 Monitoring Ambient Air Pollution

(1) Air Pollution Monitor

SO_2, CO, NOx (nitorogen oxide NO and nitogen dioxide NO_2), HC (total hydrocarbon THC, non-methane hydrocarbon NMHC and methane CH_4), ozone (O_3), and suspended particulate matter (SPM) are typical air pollutants given off from the burning of fossil fuels. These air pollutants are harmful both to human health and to the environment. Horiba has been active in developing various types of air pollution monitors since the early 1960s.

The AP-360 series of air pollution monitors[8] is used for the measurement of CO, NOx, HC, O_3, and SO_2, with the analysis method varying depending on the gas: NDIR is used for CO; reduced pressure chemiluminescence for NOx; flame ionization detection for HC; UV absorption for O_3; and UV fluorescence for SO_2. This series of monitors is notable for its use of cross-flow modulation to provide continuous, stable measurements over a long period of time for even slight changes in concentration of only a few parts-per-billion. The automated operations of these monitors ensures that operation and maintenance are easy even for an operator without specialized training.

For many years now, Horiba has been supplying air pollution monitoring agencies and other bodies around the world with a wide range of monitoring equipment: complete air pollution monitoring stations consisting of an analyzer, sampling system, automatic calibration device, and data acquisition device housed in a sturdy container able to withstand outdoor installation, and an air pollution mobile analysis van containing this equipment. The stable operation of these systems in Europe, North America, the Middle East and elsewhere has given Horiba a global reputation for quality and reliability[9].

(2) Acid Rain Monitoring Kit

Acid rain is a serious consequence of air pollution, and has a devastating effect on forests and plants. However, the accurate measurement of acid rain poses several problems. The acidity of rain when it first begins falling and after some time has passed in many cases differ. Also, since the rain contains many dissolved substances, the degree of pollution cannot be accurately assessed by simply measuring a single rain sample. The acid rain analysis kit[10] developed by Horiba includes an automatic rain collector (the Raingoround) for sequential sampling of rain after each 1 mm of rainfall , a compact pH meter able to measure samples of only one drop, and a conductivity meter. This system provides even non-specialists with firm and accurate chemical data, and is ideal for regional and scientific environmental preservation activities. Its ease of use and low cost allow it to be applied to even such things as preparing teaching materials for elementary and junior high school students.

(3) Carbon Dioxide Concentration Analyzers for Background Air

Increases in CO_2 concentration in the atmosphere have been cited as a cause of global warming.

The World Meteorological Organization (WMO) has called on countries to cooperate in the implementation of the Background Air Pollution Monitoring Network (BAPMoN)

Table 2 Air Pollution Monitor Line-up (AP-360 Series)

Model	Measuring Principles	Applications
AP-360 Series Air Pollution Monitor	Dry method	Environmental monitoring by national and local government (monitoring stations) Regional environmental monitoring (monitoring containers) Mobile environmental monitoring (monitoring vans)
APMA-360	CF-type non-dispersive infrared absorption technology (NDIR)	Monitoring of CO concentration in ambient air
APOA-360	CF-type UV absorption method	Monitoring of O_3 concentration in ambient air
APNA-360	CF-type chemiluminescence method	Monitoring of NOx concentration in ambient air
APHA-360	CF-type flame ionization detection method	Monitoring of HC concentration in ambient air
APSA-360	UV fluorescence method	Monitoring of SO_2 concentration in ambient air
APDA-360	Bata ray absorption method	Monitoring of SMP concentration in ambient air

for measuring CO_2 in the ambient air. As part of this program, the Japan Meteorological Agency has been using Horiba ambient air carbon dioxide analyzers[11] at monitoring stations on Minamitorishima Island in the Pacific Ocean and Yonagunijima Island in the Okinawa Islands.

The measurement principles and applications of HORIBA's AP-360 series air pollution monitors are shown in **Table 2**.

3.2 Monitoring Water Pollution

(1) Water Quality Monitor

The quality of water in rivers and lakes directly affects the quality of our lives. Horiba has developed the WARA series of water quality monitors to help preserve these water environments. WARA series monitors, supplied to environmental agencies in several regions, contain a sampling system with measuring instruments for basic water quality parameters, including the pH, ORP, dissolved oxygen (DO) content, conductivity, temperature, and turbidity. These monitors are installed near the monitoring source, and sample water is automatically collected and continuously measured. The measurement results are recorded at site, and then transmitted to a central station. Each monitor employs several measurement techniques: the glass electrode method for pH; metal electrode method for ORP; cartridge-type galvanic cells method for DO; the alternating bipolar method for conductivity; and light scattering transmission for turbidity.

Horiba also supplies a range of other water quality measurement systems. The company's analyzers using UV oxidation technology are used for measuring total nitrogen and phosphorus, two factors cited in the eutrophication of lakes and closed sea areas. Another factor in water pollution, Chemical Oxggen Demand (COD), has been established by the Japanese government as the reference index for measuring organic pollutants in sea areas or rivers and lakes. In this field, Horiba produces the CODA series of automatic COD analyzers[12], and the series has been widely used for monitoring factory effluent.

(2) Portable Water Quality Checker[13]

Horiba's water quality monitors include the portable U-10 water quality checker. The U-10 is easily moved from one measurement site to the next, and can measure the same six basic water quality parameters as the WARA series. Moreover, with the insulated cable connecting the instrument with the sensor, the sensor assembly of the U-10 can be directly submersed in water, thus allowing usage for a wide variety of measurement applications. With the addition of the WP-100 portable water quality monitor, the U-10 sensor can be converted into a highly cost-effective stationary

Table 3 Measuring Principles and Applications for HORIBA Water Quality Monitors

Model	Measuring Principles	Application
CODA-200 Series Automatic COD Monitors	Sulfuric acid acidic potassium permanganate method (CODA-211) Alkaline potassium permanganate method (CODA-212)	Monitoring of COD in factory effluent, river water, and sea water
OPSA-120 Organic Pollutant Monitor	Cell-length modulation system UV absorption spectrophotometry	Monitoring of organic pollutants in factory effluent, river water, and sea areas
TONA-200 Automatic Total Nitrogen Monitor	Alkaline potassium peroxodisulfate and UV oxidative decomposition / UV absorption method	Monitoring of total nitrogen concentration in river water, lake and marsh water, closed sea regions, and factory effluent
TOPA-200 Automatic Total Phosphorus Monitor	Potassium peroxodisulfate and UV oxidative decomposition / molybdenum blue absorption spectrophotometry	Monitoring of total phosphorus concentration in river water, lake and marsh water, closed sea regions, and factory effluent
WARA Series River Water Quality Automatic Monitor	pH: Glass electrode; Turbidity: Lens condensing type forward scattering transmission; Dissolved oxygen: Galvanic cell; Conductivity: Alternating bipolar method; Temperature: Thermistor	Continuous measurement of water quality (pH, dissolved oxygen, conductivity, turbidity, and temperature) in rivers, lakes, and marshes
OCMA-300 Oil Content Analyzer	S-316 extraction non-dispersive infrared absorption method	Measurement of the oil content in sample water
FLIA-100 Automatic Fluoride Ion Monitor	Fluoride ion electrode method	Measurement of the fluoride ion concentration in factory effluent

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continuous sampling and data processing system for water quality monitoring. This configuration has proven especially popular in developing countries. The measurement principles and applications for Horiba water quality systems are shown in **Table 3**.

4. General-purpose Analyzers for Laboratories and Recycling Programs

The above sections describe systems for direct measurement of the atmosphere and hydrosphere, particularly for continuous monitoring purposes. In addition, sample analysis in laboratories is also essential to finding effective solutions to environmental problems. Take for example Horiba's continuous gas analyzer. In continuous gas analysis, dust contained in sample gas must be removed before supplying the gas to the analyzer. In the development of the sampling system for its analyzer, Horiba was able to draw on valuable data provided by its particle size distribution analyzer[14] on the effects of the dust removal device. Horiba offers various other laboratory equipment as well. In the area of element analysis, the Horiba MESA-500 energy-dispersive X-ray fluorescence analyzer[15] can provide basic data on the composition of automobile parts in the wrecking process for efficient recycling. The FT-700 FTIR spectrophotometer[16] and the XGT-2000 micro X-ray analyzer[17] are also used for similar applications. In the coming years, these systems are expected to contribute to the efficient recycling of used materials.

Conclusion

Environmental problems have become a universal concern. But environmental preservation and monitoring are impossible without effective and accurate analyzing equipment. While some pollutants are already regulated, many more, often present only in minute quantities, are likely to be regulated in the very near future. For this reason, finding effective methods for measuring these pollutants is a pressing environmental concern. Moreover, the interrelated issues of environmental preservation, energy conservation, and recycling all require continuous measurement of pollutants at the site and the finding of solutions at the laboratory.

Horiba has long been a leader in analyzer technology in both these areas, and has built an impressive reputation in the field of environmental conservation. These efforts were acknowledged in June 1997, when Horiba became the first dedicated instrument manufacturer in Japan to receive the International Standards Organization's ISO14001 certification for its environmental management system. Horiba is committed to the continued development of advanced analytical instruments to further contribute to global environmental preservation.

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