Environmental Monitoring at HORIBA Europe

Past, Present and Future

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Abstract

Environmental monitoring has a long and sound tradition in Central Europe due to the early awareness of the people about the adverse effects of environmental pollution and a consequent stipulation of measures to protect the environment. In view of this situation, HORIBA Europe GmbH (HE) already started more than 25 years ago to contribute with its activities to mainly monitoring the ambient air as a prerequisite for the improvement of the overall environmental quality. Generally, the situation was drastically improved since then, yet it still did not achieve the desired level, particularly looking at countries in the South and East of Europe. Our products and know-how would contribute to solve these problems.

1 Introduction

HORIBA is active in Europe since 1972 and grew to a company with 255 employees at present, with 105 working out of Germany. The headquarter is located in Germany close to Frankfurt am Main with subsidiaries in Austria, France, UK and affiliated offices in the Czech Republic, Italy, Moscow, Netherlands and Sweden.

Initially, HE was not directly taking care of the environmental monitoring business, but cooperated with the company Axel Johnson from Sweden for sales and systems engineering. This partnership started in 1983, right after the decision to present the AP-300 series to the market. HORIBA acquired this part of Axel Johnson ultimately in 1987 after they decided to stop their activities in Germany. Subsequently, HE opened a facility in Langenfeld close to Duesseldorf to produce and sell environmental monitoring systems.

2 Brief History and Overview of Ambient Air Protection and HE's Analytical Involvement

Air pollution is usually defined as the presence of substances in the atmosphere; resulting either from human activity or natural processes, present in sufficient concentration, for a sufficient time and under circumstances such as to interfere with comfort, health or welfare of persons in the environment (Calvert, 1990)[1]. Air pollution actually exists since humanity uses the fire. Notorious in the 20th century were the "London Smog" episodes with their sad peak from December 5 through 9, 1952 killing some 4000 people and reaching maximum 24 hours SO_2 levels of 3.8 mg/m^3, (compared to a today's 24 h limit value of 0.125 mg/m^3 according to the European daughter directive 1999/30). Consequently, ambient air protection regulations were enforced in most of the industrialized countries (USA 1955, UK "Clean Air Act" 1956, Germany 1959). Due to the increase of fossil fuels burning and car traffic, ambient air pollution came to the fore since 1970 with main emphasis put on sulfur dioxide and dust in the beginning with later increasing significance of carbon monoxide, oxides of nitrogen and as secondary air pollutant ozone. Additionally, the role of organic air pollutants and their fate in the atmosphere is subject of thorough investigations (Baumbach, 1990)[2]. Table 1 shows Air Quality Limit Values of the EU Framework Directive 96/62/EC and affiliated daughter directives.

Table 1 Limit Values of the EU Framework Directive 96/62/EC and Affiliated Daughter Directives for Ambient Air Quality Assessment and Management

Component	Hourly Limit Value	Annual Limit Value	Daughter Directive
SO_2	350 µg/m³	125 µg/m³ (24 h)*1	1999/30/EC
NO_2	200 µg/m³	40 µg/m³	
PM_{10} including soot	50 µg/m³ (24 h) *1	40 µg/m³	First stage
	50 µg/m³ (24 h) *1	20 µg/m³	Second stage
Pb		0.5 µg/m³	
O_3	120 µg/m³ (highest 8 hour moving)		2002/3/EC
Benzene		5 µg/m³ (2010)	2000/69/EC
CO	10 mg/m³ (highest 8 hour moving)		
PAH	In preparation (4 th daughter directive)		
Cd, As, Ni, Hg	In preparation (4 th daughter directive)		

*1: 24 h limit value

In view of the expansion of the European Union (10 accession states will become member in spring 2004), a new EU Council Directive on ambient air quality assessment and management (96/62/EC)[3] was implemented in 1996 with four daughter directives following in the years 1999 through 2003. These directives define the principles of a strategy to assess the ambient air quality in Member States based on common methods and criteria, e.g. by stipulating pollutants, concentration limits and minimum numbers of monitoring sites. Concurrently, the German TA Luft (2002)[4] was adapted, fixing additionally the pollutants and acceptable limits for emissions from point sources like smokestacks along with regulations for Continuous Emissions Monitoring Systems (CEMS). For limiting and mitigating emissions, still the German legislation (13 BImSchV*2 for large power plants and 17 BImSchV for incinerators) is setting the standards, but similar regulations exist in most of the EU countries.

*2: "Bundes Immissions Schutz Verordnung" - "Federal (German) decree for the protection of the ambient air"

Parallel to and to keep abreast of the development of a stringent legislation, HORIBA introduced ambient air and stack gas monitors in the European market. In Japan, HORIBA already presented in 1964 with the APMA-1 the first "dry" (based on physical principles) NDIR (Non-dispersive Infrared) analyzer for CO measurements in the ambient air. The first big European project could be realized with AP-2000 series air pollution monitors in 1977 for the Environmental Bureau in Madrid, Spain followed by a major order for Kuwait, also under supervision of the HE group.

The major step towards a modern and still up-to-date concept was done during the European presidency of Dr. Kozo Ishida (current Vice President of HORIBA, Ltd.) in 1982. He decided to introduce the concept of individual analyzers for each pollutant, working with reference physical measurement principles and to fit into a 19" rack cabinet. These principles, as given in the table below, are still state-of-the-art for trace gas measurements. Table 2 shows the reference physical measurement principles.

Table 2 Measurement Principle for Each Pollutant

Pollutant	Measurement Principle
Sulfur Dioxide (SO_2)	Ultraviolet Fluorescence (UVF)
Carbon Monoxide (CO)	Non-dispersive Infrared (NDIR)
Oxides of Nitrogen (NO_x/NO/NO_2)	Chemiluminescence (CLD)
Ozone (O_3)	Non-dispersive Ultraviolet Absorption (NDUV)
Hydrocarbons(THC/CH_4/nmHC)	Flame Ionization (FID)

As the result, the AP-300 series was born, the first analyzer series precisely fitting the needs of Western markets. Since then, an unprecedented triumphal march of HORIBA's AP series in European markets started with currently the third generation AP-360 CE in place, replacing 1994 AP-350, which was in the market since 1988. All current analyzers have the pertinent approvals according to European standards and the US-EPA designation. Through the years, HE gathered comprehensive experience in systems engineering to meet the requirements of demanding clients. To offer a complete range of monitoring solutions, key system components are developed and produced, namely:

1) Sampling Systems: Sampling systems are designed and built to meet precisely the high demands of the German network standards according to the "Guidelines for location and design of automatic measuring stations in telemetric ambient air monitoring systems". All parts in contact with the sampled air are made out of boro-silicate glass. PTFE is used only to connect the glass tube to the analyzers. The total air intake is about 10 times the required flow from the analyzers. This enables pulsation free sampling and helps avoiding condensation by high gas velocity inside the tube.

2) Calibration: The requirements regarding data quality are constantly tightened up. Consequently, high-level calibration becomes more and more an indispensable prerequisite to ensure traceability of results. Traceability means the pathway back to the true value. For traceability to exist, there must be an unbroken chain of comparisons between the sample and a National / International Measurement System. The most common methods to calibrate ambient air pollution analyzers are given in Table 3.

Table 3 Calibration: Frequently Used Methods for Ambient Air Pollution Monitoring

Component	Zero gas	Testing/Calibration gas
SO_2 / H_2S	Synthetic Air / Scrubber	Calibration gas bottle, mainly permeation
NO / NO_2	Synthetic Air / Scrubber	Gas phase titration (GPT) NO Gas bottle NO_2 Permeation with NO_2/NO converter
O_3	Scrubber	UV Lamp or Silent Electrical Discharge
CO	Synthetic Air / Scrubber	Calibration gas bottle
THC / C_nH_m	Synthetic Air	CH_4 Calibration gas bottle CH_4 / C_3H_8 Calibration gas bottle

Our equipment for calibration or routine performance checks ranges from single-component, single calibration point units (so-called span check devices) up to full-fledged multi-component, multi-concentration calibrators. Most of the models can be offered as stationary as well as portable units along with the corresponding zero gas supply for calibrating the instrument's zero point. For daily routine performance surveillance, however, solutions integrated in the analyzer itself are preferentially offered, like internal ovens with permeation tubes for volatile substances (SO_2, H_2S, NO_2), valve combinations for the application of calibration gas cylinders or ozone generators. Internal zero gas supply is available by means of in-built scrubber units. In total, we can offer about 100 different models and solutions for calibration purposes.

3) Data Logging and Software: In this field, it is inevitable to provide very flexible solutions. Monitoring software must enable the client to store data and prepare reports to fulfill regulatory requirements and it must facilitate to control all monitoring equipment remotely. Our portfolio can be summarized like this:

- Communication protocols: Besides the standard protocols for data communication, we have adapted some of the protocols of our competitors to integrate their analyzers in our networks.
- Datalogger with serial interfaces inside the analyzer: We use proprietary datalogger boards for connecting our AP analyzers and to store and transfer data. We have additionally datalogger in our portfolio to connect devices having only analogue outputs. Datalogger are available along with special software also for emissions monitoring.

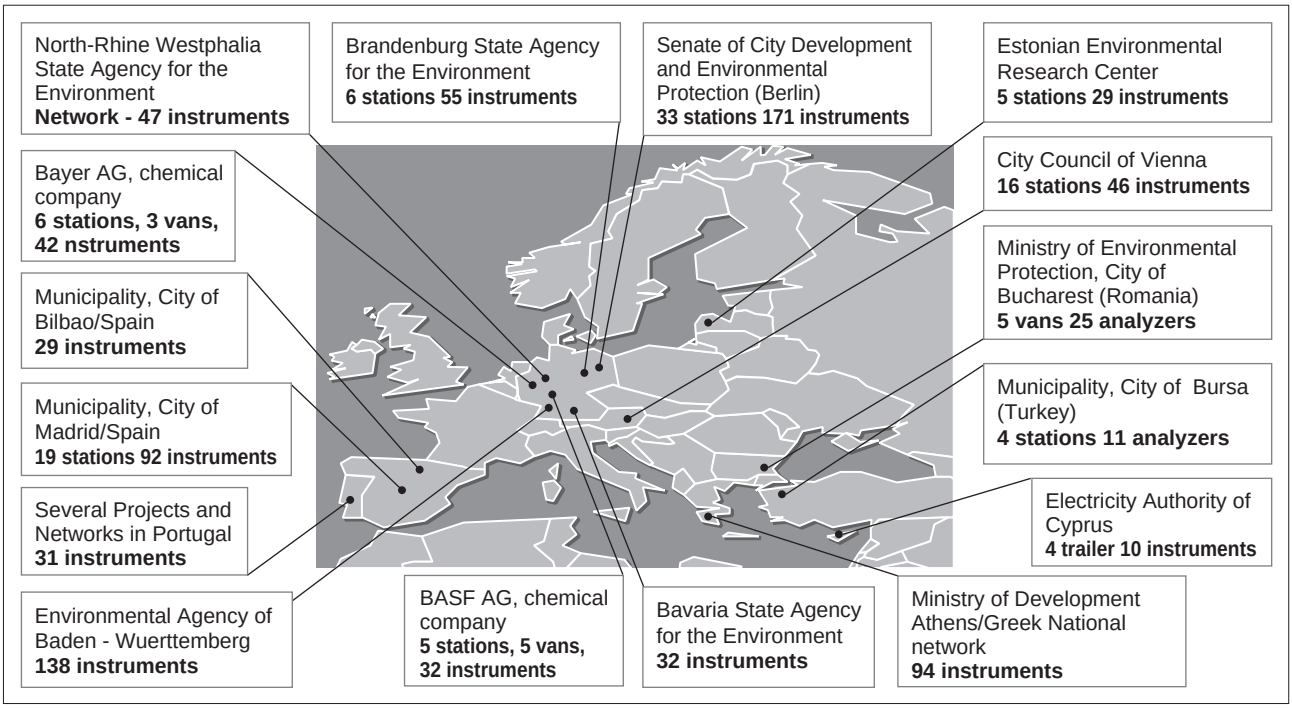

Fig.1 Major European References for Ambient Air Pollution Monitoring Analyzers and Systems

- Software to operate equipment in monitoring stations or mobile laboratories: This solution is used, if a client wants to visualize data and to create reports on-site. Such station software is normally linked via modem to a data-management center.
- Software for a data management or network center: With this software - besides storing data in large databanks and creating reports - the analytical equipment in monitoring stations can be remotely controlled and the data routinely retrieved via modem or mobile phone communication. Using such software, there is no need for an extra PC in the station. Recently, we developed software for emulating the analyzer front panel to operate it by mouse clicks from the office.

All software runs on Windows® operating systems.

4) Systems Engineering: All above-mentioned items along with analyzers and other equipment are integrated in our premises in standalone shelters, trailers, vans, and large trucks or can be installed aboard vessels. We have built e.g. more than 125 mobile laboratories. With specially adapted sampling and air-conditioning concepts, we can cope with all different climatic conditions and humidity levels.
Based on our vast experience as well as our development and production capabilities, HE was able to win projects for the supply of complete monitoring networks (Fig.1, highlighting the major European references). Two recent examples of complete monitoring systems can be found in Fig.2 and 3.
Also for CEMS HORIBA introduced successfully analyzers and systems. The milestones to be named were model EN-1000 stack gas analyzers (1988), model 510 for general-purpose gas analysis (1991), model EN-600 stack gas analyzers and the PG-2XX portable gas analyzer (Fig.4). The latest innovation is the successor of the 510 series, the VA-3000 series of general-purpose gas analyzers introduced in the beginning of 2003. Needless to say that HORIBA relies also in this field purely on physical measurement methods.

Fig.2 Ambient Air Pollution Monitoring System with AP-360 Analyzers. Interior of a Station of the Reykjavik (Iceland) Network, supplied 2002

Fig.3 Mobile Laboratory for Ambient Air Quality Control, South African Bureau of Standards, supplied 2001

Fig.4 PG-250 Portable Multi-component Emissions Analyzer

3 Actual Market Situation

Generally speaking, environmental monitoring markets are politically motivated, highly price sensitive and negatively motivated. In other words, clients often purchase only for the reason being forced by legislation to do so:

1) Central, North and partially South Europe (Italy and Spain in particular):
   - Ambient air and emissions monitoring markets are due to the long tradition in a very mature stage and consequently stagnating. Main business can be expected from replacing analyzers of age or outdated generations. Main emphasis will be put on monitoring particles (PM_{10} and / or $PM_{2.5}$) in the years to come anyway, as in many areas the promulgated limits will be exceeded. In the above regions, HORIBA's market position is double-edged:
   - For ambient air analysis, our chance to take advantage of this replacement business is quite likely, as our market share is considerable in numerous countries (Fig.5 and 6) supported by our reputation to offer unrivalled analyzers in terms of performance. Nevertheless, price becomes more and more the key to success. We expect a shift of budgets to extend the particle measurement capacities due to the high significance of particle monitoring.

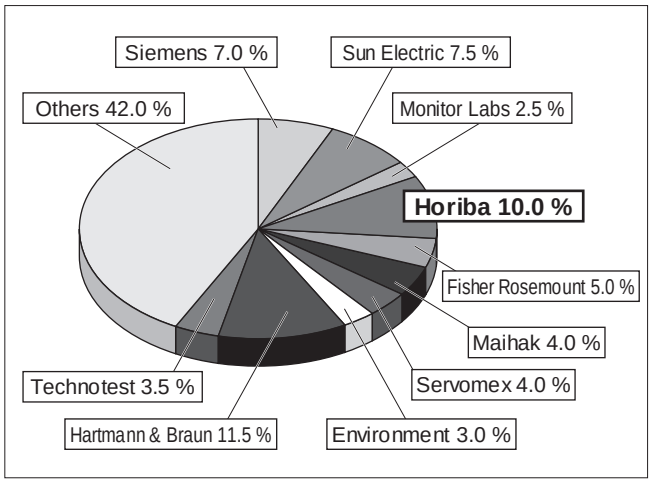

Fig.5 Overall Ambient Air and Emissions Monitoring Market Shares 1998 (Modified after "European Air Pollution Monitoring Equipment Markets, Frost & Sullivan, 1999") [5]

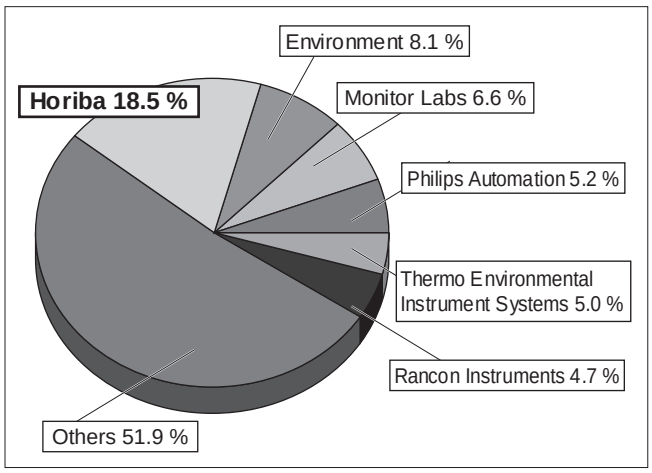

Fig.6 Market Distribution for Ambient Air Monitoring Analyzers and Systems, 1998 (Modified after "European Air Pollution Monitoring Equipment Markets, Frost & Sullivan, 1999")[5]

   - For CEMS, markets are governed by a general weakness due to slow power plant construction. Our business is additionally strongly hampered by the current ENDA system set-up, which cannot be used for replacement, as a dedicated sampling unit is required. On the other hand, the VIA-510 concept with single component analyzers is quite expensive. Here, we strongly rely on the new VA-3000. Three gases can now be measured with one instrument including CLD for NO_X and 4ways to measure oxygen. Another decisive factor in this business, delivery time, is supposed to be shortened significantly down to only a couple of weeks. The particular highlight, however, is the PG-2XX series, which is sold in substantial quantities in numerous countries like Italy, France, UK, and Belgium etc. This is stimulated by regulations requiring CLD for NO_X and Paramagnetic Sensors for Oxygen.
   - One strategy to expand the business in these "old markets" is to identify non-ambient, industrial applications for our trace-level gas analyzers. Amongst these are quality control in specialty gas production, explosion protection systems, clean room and detectors for elemental analysis.

2) East and North East Europe (old East Block countries, Russia, Baltic and CIS states), Middle East and parts of Africa:
   - Ambient Air Monitoring: Many projects are ongoing in those countries of the former East Block being accession candidates of the EU, as it is mandatory for new EU members to be compliant with the EU framework directive. Russia and the

CIS will follow with the market development initially being restricted to the oil and gas industry. In Africa, some markets like North and South Africa will pick up. In many developing countries, however, funding projects, e.g. by the World Bank might be initiated. In the Middle East, particularly in Saudi-Arabia, Arabian Emirates, Kuwait and Iran, markets are emerging. Our chance to establish a good market position in these countries depends, however, to some extent on their political relationship to countries with strong competitors like France and UK. We are traditionally very strong in Iran since decades.

- For CEMS, many countries and even regions have their own regulations or no legislation at all. The old East Block countries show the most promising market developments presently. HORIBA Austria was able to establish in countries like the Czech Republic or Slovakia a substantial market position based on the success of ENDA-1000. PG-2XX is also promising, as particularly countries having very little infrastructure of CEMS, take advantage of the comparatively low cost and portability of this instrument. Inferior equipment like electro-chemical cell instruments appears as strong competitors in these very price conscious markets.

4 Alliance among HORIBA Group Companies

Based on this long tradition with ambient air monitoring in Europe, HE intensely strives for supporting other group companies like HORIBA Instruments Incorporated / USA, HORIBA Instruments Limited / Singapore and even HORIBA Ltd. / Japan. Mainly our systems products and know-how is requested in their markets. This cooperation shall ultimately lead to a substantial penetration of such promising markets as China, India and Brazil.

5 Conclusion

Generally speaking, the overall market for environmental monitoring will definitely increase for both ambient as well as source monitoring, as many countries worldwide do not yet even have agreed upon proper regulations. We are already facing, however, many saturated markets and severe price battles due to strong competition. Nevertheless, with strong sales endeavors, appropriate product portfolios and strong cooperation amongst the group companies, we will even be able to reinforce our present high level market share. Furthermore, we must accomplish to strongly and actively increase our customer base for non-environmental applications of our high performance and high quality gas analyzers. By achieving this, we will enjoy a long-term and brilliant future.

Reference

[1] J.G. Calvert: Glossary of Atmospheric Chemistry Terms - Pure and Appl. Chem., Vol 62, No.11, pp 2167-2219, 1990

[2] G. Baumbach: Luftreinhaltung - 431 pp, Springer, 1990

[3] Council Directive 96/62/EC on ambient air quality assessment and management as of September 27, 1996 - Official Journal of the European Communities No. L 296/55 (with daughter directives 1999/30/EC, 2000/69/EC & 2002/3/EC)

[4] TA Luft (1. BImSchVwV: TA Luft - Technische Anleitung zur Reinhaltung der Luft - Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz as of July 24, 2002-GMBl. Nr. 25-29 as of 30.07.2002, page 511)

[5] European Air Pollution Monitoring Equipment Markets, Market Engineering Consulting Report 3682-15, Frost & Sullivan, 1999”

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