Review

Aims to Contribute to the Global Environment and the Economic Activity

Shinya NAKAMURA

Satoshi INOUE

Katsunobu EHARA

Naoto BANDO

Introduction

The process and environmental business has changed as the industry has developed. In the stage after high economic growth, environmental pollution such as air and water pollution became more serious, and environmental regulations and ordinances have been put into effect. To meet the requirements in these regulations, the HORIBA Group has incorporated new technology into its core technologies, Non-Dispersive Infrared analysis (NDIR) and pH meter technology, and has developed analyzers that meet the needs of the environmental analysis market. In 2011, the hydrogen explosion at the Fukushima Daiichi Nuclear Power Plant caused by the Great East Japan Earthquake scattered radioactive substances around Fukushima Prefecture. At the time, the HORIBA Group quickly donated radiation meters to the local government, and contributed to the city residents' ability to measure radiation. In this way, the process and environmental products have provided peace of mind and safety to the world for environmental pollution and environmental problems caused in each era, from the perspective of 'environmental measurements that make invisible things visible'. The process and environmental business is not limited to environmental measuring equipment--it has also contributed to the development of the industry by applying technology to measuring industrial processes. Since the 1960s, along with Japan's industrial development, many crude oil refineries and petrochemical plants were built in Japan, and the need for process gas analyzers increased. The HORIBA Group acquired explosion-proof certification and provided explosion-proof gas analyzers for processes. In the field of water quality analysis products, HORIBA has contributed to activities for sustainable water resources by helping control the water quality of water and sewage, and has supported important industrial processes with temperature monitoring and temperature control by way of its radiant-temperature thermometer, which is non-contact and can measure temperature with high precision.

In developing countries with pronounced economic growth, such as Asian countries, environmental problems such as air pollution, PM2.5, and water shortages are becoming more serious. At one time, there were almost no environmental laws or regulations, but there has been a gradual increase in the enforcement of these and now the trend is toward compliance, so the demand for environmental measurements is increasing. On the other hand, in developed countries with mature economies, due to the increased awareness of the environment, new needs for environmental measurements are increasing as a part of Corporate Social Responsibility (CSR). CSR compliance is not just about contributing to society or improvement activities-

-now companies are aiming to create profit through CSR compliance activities. Since the era of simple measurements, a new market (measurements that increase corporate value) is making an entrance.[1] In this way, the need for environmental measurements becomes more diverse along with changes in society and the times, and is spreading globally. Environmental and process products have a heavy responsibility because they are needed in all situations in each era. We would like to introduce the gas, water, temperature, and radiation meters that allow us to study daily measurement technology to meet these expectations.

Gas Measurement Business

It is very important for gas measurement devices, to control the effects of external disturbances with a high precision, continue to take measurements without problems, and be easy to use when taking measurements. To achieve these things, before introducing the gas to be measured into the gas analyzer, it is necessary to do various processing in the sampling area, and decide which measuring principles to use to suit the individual conditions. HORIBA developed many measuring principles starting in an early stage, improved sampling, and used different principles based on the needs.

In Japan, during the 1950s to 1960s, the health hazards caused by exhaust gas from smokestacks became a major social problem, and in 1968, the Air Pollution Control Law was established. To meet the new requirements, the HORIBA Group released the ESDA Sulfur Dioxide (SO_2) meter, the HORIBA Group's first gas analyzer model for smokestacks. Even now, ESDA has a Non-Dispersive Infrared (NDIR) analyzer installed, which is one of HORIBA's core technologies. The later ENDA Series added a Nitrogen Oxide (NOx) meter, Carbon monoxide (CO) meter, Carbon dioxide (CO_2) meter, Oxygen (O_2) meter, and Ammonia (NH_3) meter, etc., and HORIBA has kept improving these until now. The minimum range of the Nitrogen Oxide (NOx) meter prescribed in the Measurement Act is the 10 ppm range of the infrared analysis method. The HORIBA Group quickly incorporated a high-sensitivity infrared gas analyzer, developed fluid modulation system (Figure 1) technology, and achieved a NOx meter 10 ppm range using the infrared analysis method. Also, exhaust gas from smokestacks contains various components that hinder measurement, such as dust, sulfuric acid mist, and moisture, and HORIBA has done many sampling improvements to remove the effects of these. Today, the HORIBA Group's ENDA Series is being used to measure the exhaust gas from smokestacks in Japan and various places throughout the world. (Figure 2)

In the air measurement field, in 1964, HORIBA released a CO meter called APMA-1. At first, companies were using a wet-type unit to measure air, but the HORIBA Group started developing and eventually commercialized a dry-type air measurement device. Because the dry type could continuously take measurements with high precision and could help control maintenance costs, this type was quickly accepted overseas. This dry-type AP Series quickly spread overseas, particularly into North America and Europe. HORIBA used measurement principles based on the measuring components to achieve high-sensitivity, high-precision measurements. The NDIR method was used for CO measurements, the Chemiluminescence method (CLD method) was used for

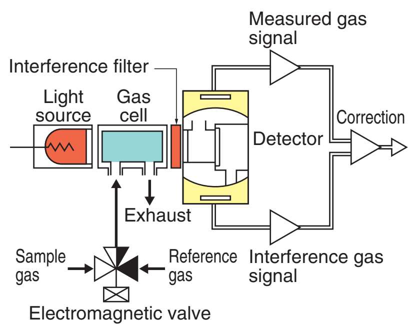

Figure 1 Structural Diagram of APMA-370 Analysis Area

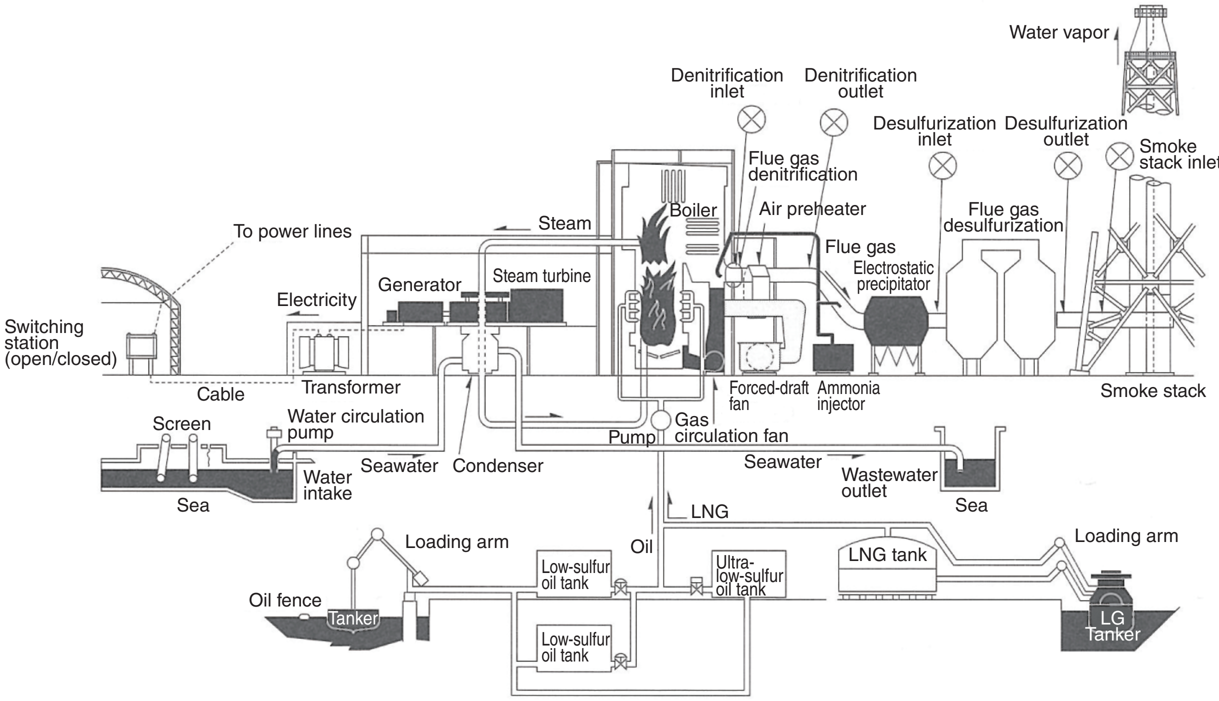

Figure 2 Power Plant Structure and Installation Locations for Flue Gas Analyzer

NOx measurements, the Ultraviolet Fluorescent method (UVF method) was used for sulfur dioxide measurements, the Ultraviolet Absorption Spectroscopy method (NDUV method) was used for O_3 measurements, and the Hydrogen Flame Ionization method (FID method) was used for hydrocarbon measurements. In Japan, the 1996 revisions to the Air Pollution Control Law recognized a dry method in addition to a wet method, and after that, HORIBA's AP Series began to be used in larger numbers, even in Japan.[2]

In the process gas measurement field, since the major industrial development in Japan in the 1960s, many crude oil refinery plants and petrochemical plants were built in Japan along with this major industrial development, and the need for process gas analyzers increased. HORIBA acquired explosion-proof certification within Japan using NDIR and provided explosion-proof gas analyzers for processes. These quickly spread from Japan into China and the Middle East.

Water Measurement Business

Needless to say, if we look at things like the population increases, environmental pollution, and climate change, water resources will become increasingly more important to us as living organisms in the future. Therefore, measuring and managing water in order to use water sustainably will become a required issue in the future. HORIBA started its business by developing a pH meter,[3, 4] and the current technology can cover many general characteristics of water, such as electrical conductivity, dissolved oxygen, oxidation-reduction potential, turbidity, residual chlorine, and various types of ions. Figure 3 summarizes HORIBA's technology seeds. These can be categorized into broad categories: Electrochemical methods, Spectroscopy methods, and other methods. Even within the electrochemical methods, HORIBA has pH technology that controls the glass membrane composition, and technology that improves durability and response. Also, in recent years, HORIBA has optimized ion-selective electrodes based on applications, and is trying to apply these to applications that were previously impossible.[5]

The Spectroscopy method mainly uses ultraviolet light and visible light. The measured areas are rotated and continuously cleaned as a countermeasure against the effects of contamination and to provide stability during continuous measurements, which is a feature of the environment and process market, and HORIBA has technology that modulates the cell length and cancels the effects of background fluctuations. Also, the infrared sensor technology from the gas measurement business is also being used as oil measurement technology.[6] In the future, HORIBA will develop products that include the HORIBA Group company Jovin Yvon's Raman scattering and fluorescence technology. In addition, in terms of other technology, there is also independent know-how on dispensing and mixing fluids, as well as reaction technology. When measuring water, in many cases a pharmaceutical is mixed in with the sample, and then things like coloring and titration value are measured. To provide stable measuring, dispensing, and reactions over a long period of time, it will be necessary to combine things like measurement devices, pumps, and electromagnetic valves.[7] HORIBA is also continuing to acquire diamond electrodes and other new technology. In particular, the annually held Masao HORIBA Awards are a good opportunity to find out the cutting-edge measurement technology being used in universities and research institutions around the world.[8] The products will not be finished only with the above technologies--they will be commercialized as more compact combined devices and combined sensors.[9-11] Furthermore, multiple product type units can be put together to create a measurement system. Figure 4 summarizes the water circulation cycle and the HORIBA Group's water measurement business's typical product line-up. Because water is a resource that circulates,

Categories	Principles	Features		
Electrochemical methods	Hydrogen ion concentration (pH)	First in Japan, tough, ISFET	Combined sensor	Products
	Electrical conductivity (Cond)	Small amount, wide range		
	Oxidation-reduction potential (ORP)	Downsized		
	Ion-selective electrode (ISE)	Various types, optimization of measurement		
	Dissolved oxygen (DO)	Reducing flow rate effects		
Spectroscopic methods	Turbidity (Turb)	Automatic cleaning, downsized		
	Particles	High sensitivity		
	Ultraviolet light (UV)	Rotary cell length modulation method		
	Visible light rays (VIS)	Rotary cell length modulation method		
	Infrared light (IR)	Complex of non-dispersive infrared (NDIR) and solvent extraction		
	Raman scattering, fluorescent light	Collaboration with HORIBA Group's Jobin Yvon		
Others	Dispensing, mixing, and reactions of liquids	Continuous operation		
	Diamond electrodes	High sensitivity, wide potential window		
	New technologies	Fluorescent film, etc.		

Figure 3 HORIBA's Technology Seeds for the Water Measurement Business

Figure 4 The Water Cycle and the HORIBA Group's Representative Product Line-Up for the Water Measurement Business

from time immemorial, humans have been repeatedly using limited water resources. Measuring and analyzing the water characteristics is the first step to objectively monitoring and controlling this circulation. In the future, we think that contributing to the sustainable use of water resources will be our reason for existence.

Temperature and Radiation Measurement Business

Monitoring and controlling temperature are important processes in industrial production, maintenance, and logistics activities, and HORIBA has been working to research and develop new temperature measurement technologies over its long history. Soon after its establishment, starting in the 1950s, the HORIBA Group developed the production and processing technology for an alkali halide crystal, an optical material in the infrared range, and began to accumulate the core technologies required for gas analysis. In the 1980s, HORIBA developed an infrared thermometer product that made it possible to measure temperatures in a non-contact manner by measuring the infrared radiation from the object, and these diligent efforts have been continued until today. Out of the core technologies that support the infrared thermometer, all of these have been developed in-house: the high-sensitivity infrared detector (Thermopile device), multi-layered infrared film filter, and the blackbody furnace that enable to calibrate the temperature readings with a high precision, and have supported the fundamentals of the HORIBA Group's high-precision infrared thermometer product line-up. HORIBA has provided products that meet the requirements of the era, starting with the IT-200 (1984), whose objective was to continuously monitor the temperature of the stored spent nuclear fuel from a nuclear power plant. The IT-500M earhole type clinical thermometer was also jointly developed and commercialized with Nissho Corporation (current name: Nipro Corporation) (1993). HORIBA also came up with "i-square," a two-dimensional infrared thermometer with the first 8 × 8 array-type thermopile device in the world installed.[12, 13] This product line-up ended and became one of our precious memories of the past, but now, HORIBA is meeting the needs of the market for high-precision, non-contact temperature measurements with the handheld IT-545 Series infrared thermometer, stationary-type IT-230 and IT-450-Series infrared thermometers, which provide the industry leading accuracy (researched by HORIBA in 2014). (Figure 5)

In the alkali halide crystal application field, in the 1950s, HORIBA began to work on developing products for the radiation measurement field using Sodium Iodide (NaI) crystals and the related applied technology. HORIBA has sold such products as an NaI(Tl) scintillator (1955), RM-2/RM-3 survey meter (1957), 12-inch Anger-type NaI (Tl) scintillator (1969), scintillator that uses Cesium Iodide (CsI) crystals (1986), the Hakarukun DX-100 (1989) environmental radiation monitor whose main objective was radiation education, and the PA-100 (1993) radiation survey meter, which have led to the currently sold environmental radiation monitor PA1000/PA-1100.[14, 15] In 1986, HORIBA received an order from Cornell University in the US for CsI(Tl) crystals (5-6 cm on each side, 25-30 cm in length, 4,000 crystals) for an accelerator detector (calorimeter) for high-energy physics. After that, HORIBA pursued the possibilities of an environmental radiation monitor that is compact and can use a dry battery drive, by combining CsI(Tl) crystals and

Earhole-type clinical thermometer
IT-500M

2D i-square infrared thermometer

IT-545-Series
handheld infrared thermometer

Figure 5 Photographs of Thermometer-Related Products a photodiode. In March 2011, the Great East Japan Earthquake triggered the accident at the Fukushima Daiichi Nuclear Power Plant, which dispersed radioactive substances, mainly in Fukushima Prefecture, which created the need to be able to measure the air dose rate easily and with good precision. Residents, local government employees and many people have started using the PA-1000/PA-1100 environmental radiation monitors at many places. In this situation, we combined the PA-1000, PA-1100 and developed a simple radioactivity measurement kit called PA-K, which can easily estimate the radioactivity in food and soil, and this was helpful in doing checks for peace of mind and safety.[16] The PA-1100 has Bluetooth technology that provides a data communication function, and by using a smart phone, it is possible to easily display mapping of air dose rates, and many sites have started utilizing this product. (Figure 6)

Infrared thermometers are significantly different from radiation meters in terms of technology, but the alkali halide crystal technology is the common origin, as a HORIBA Group core technology. In the specialized engineering development flows, HORIBA has worked to meet the needs of the times by always having and cultivating core technologies such as detectors and their peripheral technologies in-house. In the future as well, HORIBA hopes to meet the needs of society by making effort and pursuing the achievement of reliable measuring instruments.

PA-1100

Air dose rate mapping

Figure 6 Environmental Radiation Monitor Photograph and Example of Air Dose Rate Mapping

Conclusion

Japan, North America, and Europe have been the drive behind the process and environmental, but in recent years, there has been pronounced growth in developing countries such as China and South Korea. To meet the requirements in the environmental laws and regulations and industrial standards in each area, HORIBA has consolidated its engineering and production functions in major locations, and is providing analyzers that suit the needs of the local area. In recent years, HORIBA has done joint research on environmental analysis with universities and research institutions in Asian countries and has given personnel from the Ministry of the Environment training on environmental measurements. In this way, HORIBA has been engaged in activities that exceed its business framework. In this way, it can be said that as a Japanese analysis instrument manufacturer, conveying Japanese knowledge and experience about environmental countermeasures is the mission of this business. In the future, as a measurement partner for our customers, HORIBA would like to provide measurement solutions that go beyond analyzers and contribute to the conservation of the global environment and the development of the industry.

References

[1] Michael E Porter, Mark R Kramer, Creating Shared Value, *DIAMOND Harvard Business Review*, 2011
[2] DNA of HORIBA "50th anniversary of HORIBA, Ltd.", HORIBA Ltd
[3] Yasukazu Iwamoto, Nobuki Yoshioka, *Readout (HORIBA Technical Reports)*, **31**, 46(2005)
[4] Yuji Nishio, Hiromi Ohkawa,, *Readout (HORIBA Technical Reports)*, **41**, 60(2013)
[5] Katsunobu Ehara, Hiroshi Nagai, *Instrumentation and Automation*, **Special issue**, 131(2009)
[6] Akio Ishii, Yuji Ito, Hiroaki Murakami, *Readout (HORIBA Technical Reports)*, **43**, 33(2014)
[7] Yuji Nishio, Ryota Kosaka,, *Readout (HORIBA Technical Reports)*, **42**, 120(2014)
[8] Ryota Kosaka, Yuji Nishio, *Readout(HORIBA Technical Reports)*, **43**, 43(2014)
[9] Yoshihiko Kawaguchi, Reiji Kopjima,, *Readout(HORIBA Technical Reports)*, **43**, 38(2014)
[10] Akio Ishii, Tadashi Kawano, *Readout (HORIBA Technical Reports)*, **42**, 125(2015)
[11] Katsunobu Ehara, *Readout(HORIBA Technical Reports) Special issue October*, 26(2013)
[12] Katsuaki Ogura, Shinya Ymaguchi, Tokuaki Tsukada, *Readout (HORIBA Technical Reports)*, **31**, 36(2005)
[13] Mitsuru Hojyo, Takeshi Mori, *Readout (HORIBA Technical Reports)*, **31**, 62(2005)
[14] YuichiroKomatsu, Katsunobu Ehara, Katsuaki Ogura, *Readout (HORIBA Technical Reports)*, **35**, 56(2009)
[15] Naoyuki Matsumoto, Yuji Tsujiok, Hirofumi Sakoda,v*Readout(HORIBA Technical Reports)*, **7**, 52(1993)
[16] Yoshiaki Nakata, Ichiro Asano, *Readout (HORIBA Technical Reports)*, **25**, 39(2002)
[17] Kyoshiro Imagawa, *Readout (HORIBA Technical Reports)*, **30**, 88(2005)
[18] Norio Itatani, Takeshi Aoyama, *Readout (HORIBA Technical Reports)*, **3**, 91(1991)
[19] E. Matsumoto, K. Tominaga, T. Saze, S. Nakayama, M. Sakama and Y. Kuwahara, "Development of a simple radioactivity measurement method using a portable dose rate meter, "Radiation Detectors and their uses" Proceedings of the 26th Workshop on Radiation Detectors and Their Uses, 17-26(2012)

Shinya NAKAMURA
Manager
Process & Environmental Segment Strategy Officer
Corporate & Segment Strategy Division
HORIBA, Ltd.

Satoshi INOUE
Manager
Process & Environmental Segment Strategy Office
Corporate & Segment Strategy Division
HORIBA, Ltd.

Katsunobu EHARA
Manager
Process & Environmental Segment Strategy Office
Corporate & Segment Strategy Division
HORIBA, Ltd.
Ph. D

Naoto BANDO
Manager
Process & Environmental Segment Strategy Office
Corporate & Segment Strategy Division
HORIBA, Ltd.